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STUDIES ON THE CONTROL OF GAS IN LIMBURGER CHEESE*[1]

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A problem confronting the makers of limburger cheese is the development of gas in the newly made cheese. In some factories the extent of this gas during the summer is sufficiently great to prohibit the manufacture of limburger and the milk is made into cheddar cheese. During the early stages of ripening of a normal limburger cheese, the body is firm and solid except for a few mechanical holes due to incomplete matting of the curd particles. Depending on the amount of gas present, a gassy cheese may have a few round holes or so many that it resembles a sponge (Figures 1 and 2). A

FIG. 1. Upper cheeses made July 7th and the lower ones July 8th. The left hand cheeses were made from raw milk and the right from the same milk heated to 63° C. (145° F.) for 10 minutes.

cheese with few gas holes usually develops into a normal cheese, while one badly blown with gas will not ripen normally and is unsaleable for direct consumption.

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* Acknowledgment should be made to the Miller-Richardson Company for aid in gathering material for this investigation, and to the Cherry-Burrell Corporation for the use of a special pasteurizer. The investigation was made possible by the Federal Bankhead-Jones Fund.

[1] Approved by the Director of the New York State Agricultural Experiment Station for publication as Journal Paper No. 271, May 31, 1938.

These results are concerned with an investigation into the cause of gas in limburger cheese and methods for its control.

FIG. 2. Lower cheeses made August 4th, the left from raw milk and the right from the same milk heated to 63° C. (145° F.) for 15 minutes. Upper cheeses made August 5th, the left from raw milk and the right from the same milk heated to 63° C. (145° F.) for 20 minutes.

THE CAUSE OF GAS IN THE CHEESE

Five cheeses which eventually developed a large number of gas holes were examined bacteriologically for total numbers of organisms and for numbers of gas-formers of the coliform group. Counts were made of the milk at time of renneting and of the cheese at intervals during the first 24 hours. Total counts were made on Tryptone[2]-glucose agar (Tryptone 0.5 per cent, glucose 0.1 per cent) with the plates incubated for 48 hours at 32° C., while coliform organisms were determined on Leifson's (1) desoxycholate agar plates, incubated 24 hours at 37° C.

Total counts of the raw milk as received during July and August (Table 1) varied from 1,800,000 to 5,000,000,000 per ml. In the milk with the lowest total count 360,000 coliform bacteria were present per ml. and 1,300,000 per ml. in the sample with the highest total number of organisms. The cheese made from these lots of milk showed counts per gram of cheese as high as 600,000,000 in the first instance with 8,000,000 coliform bacteria and 2,200,000,000 in the second instance with 50,000,000 coliform organisms. Although this milk was unsatisfactory for limburger cheese, when milk from the same supply was used in making cheddar cheese, a satisfactory product was obtained. The total counts and ratio of numbers of coliform bacteria to total numbers of bacteria are not greatly out of line for raw milk that has not been under laboratory control; see Harrison et al. (2); Ayers and Clemmer (3).

It is of interest to note that where the heated milk had coliform counts of 21 and 12 per ml. respectively, some gas was to be found in the cheese made

[2] A casein digest peptone.

TABLE 1

Bacterial counts of gassy limburger cheese during the making process

Sample	Time after renneting	Total count on Tryptone-glucose agar	Coliform count on desoxycholate agar	Ratio coliform count to total count
July 6th	*hrs.*			
Raw milk*	0	240,000,000	150,000	1: 1,600
Heated to 63° C. for 10 min.		6,000	< 100	
Raw cheese[1]	1	240,000,000	< 1,000	
Raw cheese	2	480,000,000	21,000	1: 23,000
Raw cheese	3	110,000,000	180,000	1: 610
Raw cheese	5	600,000,000	180,000	1: 3,300
Raw cheese	8	400,000,000	280,000	1: 1,400
Raw cheese	24	200,000,000	1,100,000	1: 180
July 7th				
Raw milk	0	1,800,000	360,000	1: 5
Heated to 63° C. for 10 min.		132,000	< 10	
Raw cheese	1		11,000	
Raw cheese	2	16,000,000	200,000	1: 80
Raw cheese	3½	20,000,000	2,500,000	1: 9
Raw cheese	5½	400,000,000	3,000,000	1: 130
Raw cheese	6½	600,000,000	8,000,000	1: 75
Raw cheese	24	800,000,000	170,000	1: 11,000
July 8th				
Raw milk	0	5,000,000,000	1,300,000	1: 3,800
Heated to 63° C. for 10 min.		88,000	21	1: 4,200
Raw cheese	1	3,400,000,000	580,000	1: 5,900
Raw cheese	2	1,500,000,000	2,000,000	1: 750
Raw cheese	3½	1,900,000,000	27,000,000	1: 70
Raw cheese	5	2,200,000,000	50,000,000	1: 44
Raw cheese	6½	2,200,000,000	26,000,000	1: 85
Raw cheese	24	1,600,000,000	4,500,000	1: 350
July 9th				
Raw milk	0	2,900,000,000	7,600,000	1: 380
Heated to 63° C. for 5 min.		14,000,000	12	1: 1,200,000
Raw cheese	1	800,000,000	180,000	1: 4,400
Raw cheese	2	1,300,000,000	130,000	1: 10,000
Raw cheese	3	6,800,000,000	50,000,000	1: 140
Raw cheese	4	1,900,000,000	34,000,000	1: 56
Raw cheese	5	2,000,000,000	74,000,000	1: 27
August 5th				
Raw milk	0	200,000,000	500,000	1: 400
Heated to 63° C. for 20 min.		110,000	< 1	1: 110,000 no gas
Raw cheese	2	980,000,000	300,000	1: 3,300
Raw cheese	3	1,400,000,000	3,400,000	1: 410
Raw cheese	5	1,600,000,000	3,400,000	1: 470

* Counts of milk—colonies per ml.

[1] Counts of cheese—colonies per gram.

from it, while when a longer holding time was maintained and a coliform count was obtained of less than 1 per ml., no gas was found in the cheese.

When the method of manufacture and the temperatures encountered are considered, it is not surprising that where coliform organisms are present a gassy cheese develops. Because it is desirable to keep down the development of acid when making good limburger, it is not the custom to add starter to the milk. While the time and temperature records used during the present study do not necessarily hold true at all times for limburger cheese, these records show how gas forming organisms of the coliform group are encouraged in the making process in general. The milk was heated at once to 30° C. (86° F.) or sligthly higher and rennet added (Figure 3). The temperature was maintained at this point for about 50 minutes when it was raised over a period of about 30 minutes to a temperature of close to 39° C. (102° F.), held for another 30 minutes and then dipped into moulds (Figure 3). For the next 3 or 4 hours, depending upon the weather, the cheeses slowly cooled to 30° C. (86° F.) or lower (Figures 3 and 4[3]) when they were moved

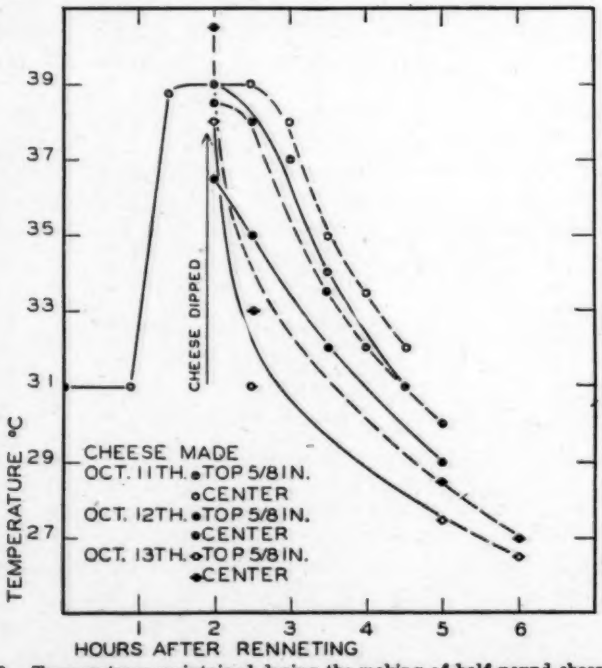

FIG. 3. Temperatures maintained during the making of half pound cheese from the time the rennet was added to the milk until the cheese was placed in the curing room.

[3] The detailed data from which these figures were constructed may be obtained by writing to the Division of Bacteriology, New York State Agricultural Experiment Station, Geneva, New York.

to the ripening room. It will readily be seen that the temperature maintained during the first 5 or 6 hours is more suitable for the growth of coliform bacteria than for the lactic acid bacteria, resulting in rapid increase of gas formers and the production of a gassy cheese. This is confirmed by bacterial counts made during the making process (Table 1), and the change in the ratio of coliform organisms to the total count. The ratio between coliform bacteria and total bacteria was found to increase materially (Table 1) so that the percentage of coliform bacteria was much higher at the end of the day than at the beginning.

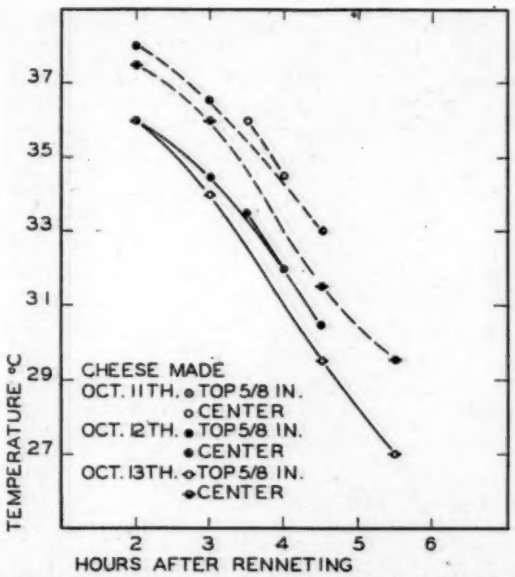

FIG. 4. Temperatures of two pound cheese from the time the curd was dipped into the molds until the cheese was placed in the curing room.

Forty colonies were picked from the desoxycholate agar plates. On further study, 20 cultures were classified as *Escherichia coli* and 20 as *Aerobacter aerogenes*. From this, it would seem that gassy cheese may be produced by either species or by both. As these organisms are commonly found in milk, particularly under certain conditions and at certain seasons of the year, they should be considered a potential source of gas, especially during the summer season.

HEAT TREATMENT AS A MEANS OF CONTROLLING GAS

Zeiler and Berwig (4), in Germany, found they could control gas in limburger types of cheese by heating the milk at 63° C. (145° F.) for 15 or 30 minutes, and make a satisfactory cheese.

During the present investigation heating studies were carried out by three different methods with cheese-factory milk. In the first two cases control cheeses made from the same milk unheated were quite gassy (Figures 1 and 2).

With the first method, 20 gallons of milk were heated in milk cans to 63° C. (145° F.) and held at this temperature for 5, 10, 15, and 20 minutes. The cheeses made from milk held for 5 and 10 minutes showed signs of gas though not as much as the controls, while those made from milk held for 15 and 20

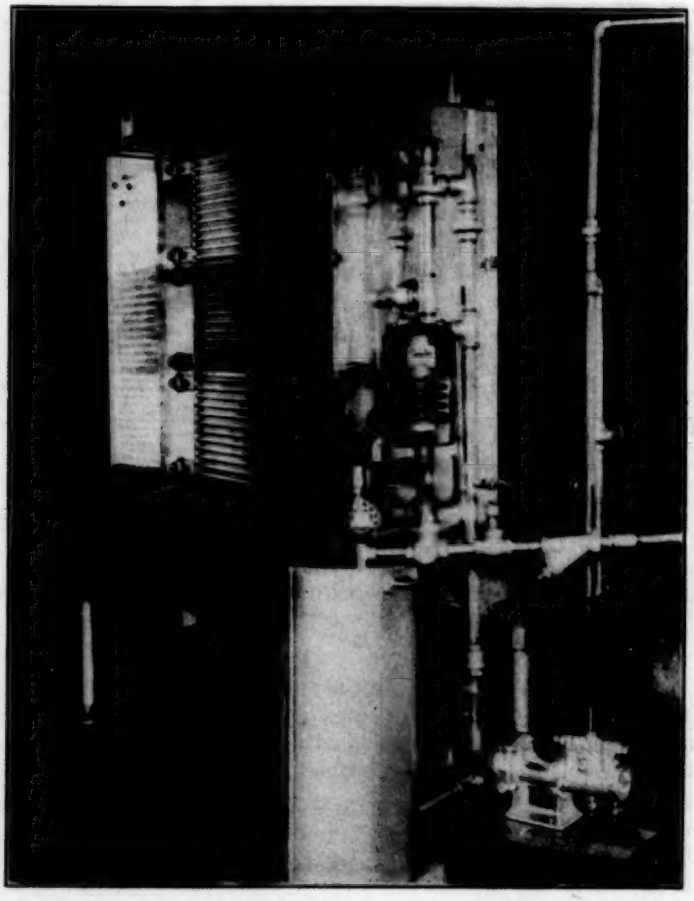

FIG. 5. The pasteurizer used for the second series of experiments. The milk was heated on the upper two sets of coils and cooled on the lower set.

minutes were entirely free of gas (Figures 1 and 2). Cheeses made from this milk were satisfactory in every respect.

For the second series of experiments, a special pasteurizer was furnished by the Cherry-Burrell Corporation (Figure 5) with which the temperature could be controlled within a range of 2 degrees and the milk cooled at once to renneting temperature. The temperature of the water was controlled by a thermoregulator in the tank and the water circulated by a pump through coils. The upper two sets of coils, where the warm water circulated, were used for heating the milk and the lower set for cooling. The milk was fed from a reservoir at the top and ran down over the coils. Temperatures of 70.5°, 81.5°, and 72.5° C. (159°, 161°, and 163° F.) were used during this series and the milk cooled promptly to 30° C. (86° F.). Forty gallons of milk were used in each case. A small amount of gas was found in the cheeses made from milk heated to 70.5° and 71.5° C. though much less than in the raw milk cheeses. The cheeses made from milk heated to 72.5° C. were free from gas. After three months, all of the cheeses made from heated milk were of excellent quality and flavor, while those made from raw milk had pronounced off flavors. The number of experiments carried out are too few to permit definite conclusions to be drawn though they do indicate that heat-

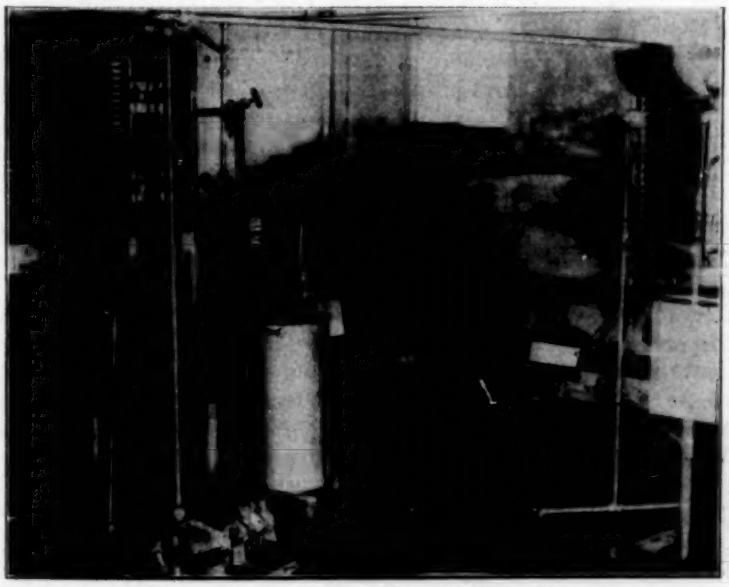

FIG. 6. The pasteurizer used in the third series of experiments. The milk was heated on the two sets of coils, held 15 seconds while passing through the pump and pipes, cooled by the cooler at right and delivered into the cheese vat.

ing to 71.5° C. and cooling immediately is not sufficient to control the gas completely.

In the third series, it was considered advisable to use a time and temperature for pasteurization of the cheese milk commonly accepted by those public health authorities who approve the high-temperature, short-time method for market milk (at least 160° F. for at least 15 seconds). Therefore, the pasteurizer was altered to give a holding time of approximately 15 seconds. This was accomplished by a milk pump, the speed of which could be controlled, at the bottom of the heater with a pipe from the pump to a cooler placed over the cheese vat (Figure 6). Two lots of cheese were made in this series, the milk being heated to 71.0° C. (160° F.) and 72.0° C. (162° F.) and the holding time controlled to 15 seconds by adjusting the speed of the milk pump. In the two trials where this pasteurizing equipment was used the raw milk cheeses were superior to those made from pasteurized milk. It should be pointed out, however, that the methods of making and curing were those practiced in this cheese factory for producing the best quality of cheese from raw milk. Further studies should be made to develop suitable methods for manufacturing pasteurized milk into limburger cheese.

DISCUSSION

As the relatively high temperatures maintained during the period of making, together with the low acidity of the milk, encourage the growth of coliform bacteria, so that gas is produced in the cheese when as few as 12 are present per ml. of milk, it is desirable that milk for making limburger cheese be comparatively free of organisms of this type. The amount of gas produced depends upon the proportion of coliform organisms to other organisms, more gas being produced where the proportion is large than where it is small.

While it is not the purpose of this investigation to suggest heat treatment as the only method of preventing gas in the cheese, it seems a method that can be utilized by the cheese maker where difficulty is encountered due to coliform bacteria in the milk as received from the farm. Systematic grading of the milk as received at the cheese factory would also do much to overcome the problem of gas formation. The desirability of pasteurization as a public health precaution must also be given consideration. This has been more fully discussed in a previous publication (5). Previously published studies at the Station (6) give data dealing with the quality aspect as related to pasteurization. Price (7) found that pasteurization at 62.5° C. (145° F.) for 30 minutes produced a better cheddar cheese than any other method of pasteurization tried.

The present data indicate that a good limburger cheese can be made from milk heated sufficiently to control gas producing organisms. Some feel that a holding method for heating the milk is not as convenient for use

in the average cheese factory as a short time method such as was used in the experiments reported here.

When a short time method of heating is used, the equipment can be so arranged as to permit milk to flow from the weight vat through the pasteurizer to the cheese vat. If equipment is used that has adequate time and temperature controls, such pasteurizers would undoubtedly be approved by health authorities if pasteurization of milk for cheese making should be made compulsory.

SUMMARY

Investigations on limburger cheese show that gas in the cheese developed because of the growth of the bacterial species, *Escherichia coli* and *Aerobacter aerogenes*. Even a comparatively small number of these organisms in the milk may cause gas in the cheese. Because the cheese is held at 30° C. or higher for the first six hours, the ratio of coliform organisms to total bacteria present increases rapidly during the period of manufacture.

Pasteurization by either the holding method or the high-temperature short-time method prevents the development of gas. The present studies show that limburger cheese of good quality can be made from milk which has been heated sufficiently to control the development of gas.

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THE INFLUENCE OF HYDROGEN ION CONCENTRATION AND SALT ON THE SURFACE FLORA OF LIMBURGER CHEESE[1]

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Two main types of microorganisms are found in the slime of limburger cheese and assumed to be responsible for the surface ripening (Kelly (1)). Budding yeast-like organisms appear first about the time the cheeses are put on the shelves and increasing rapidly in numbers make the surface of the cheese slimy. Later red pigment-producing, rod-shaped bacteria replace the yeasts and make the slime red and more like butter in consistency.

In speculating as to the factors contributing to the development of the two types of microorganisms to the almost total exclusion of all other types, and the definite sequence with which the rods followed the yeast forms it was thought that salt and hydrogen ion concentration, together with temperature might play a part. Accordingly, cultures of the organisms were isolated and examined as to the influence of these factors on their development.

Macy and Erekson (2) studied the slime of a Roquefort type of cheese and of Port du Salut cheese. Large numbers of *Streptococcus lactis* were found on the surface of the Roquefort cheese before salting, but after salting they disappeared almost entirely and were replaced by yeast forms. As the yeasts increased the pH rose from 4.8 to 5.0. At 21 days the pH was 5.9 and the yeasts started to disappear and were replaced by rods. At 6 weeks the pH was 7.3, red color was found in the slime and torula, rods and cocci as well as *Penicillium roqueforti* were present. In the interior of the cheese the pH was 4.8 when one day old and changed little during six weeks.

The slime of well-developed Port du Salut cheese had a pH of 7.5 to 7.6, with rods predominating. Large numbers of organisms of the *Bacterium linens* type together with some degenerated forms of torula appeared in microscopic preparations. Examinations of the slime of Tilsiter and old Limburger cheeses showed characteristics similar to those of Port du Salut.

INFLUENCE OF pH, SALT, AND TEMPERATURE ON THE ORGANISMS TOGETHER WITH THEIR ACTION ON CERTAIN CARBON AND NITROGEN COMPOUNDS

The cultures of the yeast forms were divided into two main groups, those represented by Cultures 65 (Table 1) growing more rapidly and producing

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[1] Approved by the Director of the New York State Agricultural Experiment Station for publication as Journal Paper No. 289, October 11, 1938.

TABLE 1

The influence of temperature and hydrogen ion concentration on the growth of yeasts from Limburger cheese

Culture 65							Culture 67						
pH	Reading days	18° C.	25° C.	30° C.	37° C.	45° C.	pH	Reading days	18° C.	25° C.	30° C.	37° C.	45° C.
3.5	1	−	−	−	−	−	3.5	1	−	−	−	−	−
	2	+	+	−	−	−		2	−	−	−	−	−
	3	++	++	−	−	−		3	−	−	−	−	−
	7	++	++	−	−	−		7	+	+	−	−	−
4.5	1	−	−	−	−	−	4.5	1	−	−	−	−	−
	2	+	++	−	−	−		2	−	−	−	−	−
	3	++	++	−	−	−		3	−	−	−	−	−
	7	++	++	−	−	−		7	++	++	−	−	−
5.5	1	−	−	−	−	−	5.5	1	−	−	−	−	−
	2	+	++	−	−	−		2	−	+	−	−	−
	3	++	+++	+	−	−		3	+	+	−	−	−
	7	++	+++	++	−	−		7	++	++	++	−	−
6.5	1	−	+	−	−	−	6.5	1	−	−	−	−	−
	2	++	++	++	−	−		2	−	+	−	−	−
	3	++	+++	++	−	−		3	+	++	−	−	−
	7	+++	+++	++	−	−		7	++	++	++	−	−
7.5	1	−	+	−	−	−	7.5	1	−	−	−	−	−
	2	++	++	++	−	−		2	−	+	−	−	−
	3	++	+++	++	−	−		3	+	+	−	−	−
	7	++	+++	++	−	−		7	++	++	++	−	−
8.5	1	−	−	−	−	−	8.5	1	−	−	−	−	−
	2	−	−	+	−	−		2	−	−	−	−	−
	3	+	+	+	−	−		3	−	−	−	−	−
	7	++	++	++	−	−		7	+	+	+	−	−
9.5	1	−	−	−	−	−	9.5	1	−	−	−	−	−
	2	−	−	−	−	−		2	−	−	−	−	−
	3	−	−	−	−	−		3	−	−	−	−	−
	7	−	−	−	−	−		7	−	−	−	−	−

−= No growth.
+= First sign of growth.
++= Good growth.
+++= Heavy growth.

a heavier pellicle on liquid media than the others represented by Culture 67. In all other respects the cultures appeared the same and are probably variants of one species.

As stated before (1) these yeast forms were found to reproduce by budding, showed no trace of sexuality, did not produce spores, formed a pellicle on liquid media from the beginning, and tolerated salt in concentrations as high as 18 and 20 per cent. They showed their best growth at a temperature of 25° C. and a pH about 6.5, though growth was observed from pH 3.5 to 8.5 (Table 1). Fructose, glucose, mannose, galactose, sucrose, maltose, lactose, raffinose, ethyl alcohol, and sodium and calcium lactate were utilized as carbon sources with the production of carbon dioxide.

Both Bacto proteose peptone and Bacto peptone were readily utilized as a source of nitrogen without any other source of carbon. A proteose peptone (3), made by salting out with ammonium sulphate and dialyzing the precipitate to get rid of the sulphate, was able to support growth in the presence of a fermentable carbohydrate but not without. Ammonium sulphate, ammonium nitrate, ammonium phosphate, and asparagin could not be used as a sole source of nitrogen in the presence of a fermentable carbohydrate.

TABLE 2

The influence of temperature and hydrogen ion concentration on the growth of Bacterium linens

Cultures 4 and 56a—*Bacterium linens*						
pH	Reading days	18° C.	25° C.	30° C.	37° C.	45° C.
3.5	2	−	−	−	−	−
	3	−	−	−	−	−
4.5	2	−	−	−	−	−
	3	−	−	−	−	−
5.5	2	−	−	−	−	−
	3	−	−	−	−	−
5.85	2		+			
	3		+			
6.0	2		+			
	3		+			
6.5	2	+	+	+	−	−
	3	++	++	++	−	−
7.5	2	+	+	+	−	−
	3	++	++	+	−	−
8.5	2	+	+	+	−	−
	3	++	++	+	−	−
9.5	2	+	+	+	−	−
	3	++	++	+	−	−

−= No growth.
+= Small amount of growth.
++= Good growth.

Gelatin was not liquefied, and a slight alkaline reaction was noted in litmus milk with reduction of the litmus at the bottom of the tube.

At the present time no attempt is made to classify these yeast forms.

The rod forms are represented by Culture 4, isolated in the present study, and Culture 56a (Table 2), obtained from Kiel. Both are typical *Bacterium linens* Weigmann.

It is to be noted that Culture 4 and other cultures isolated in this study produced the typical orange-colored ring in milk in contrast to that previously reported (1).

Bacto peptone was readily utilized both as a carbon and nitrogen source, but asparagin, ammonium sulphate, and ammonium nitrate could not be used. No apparent action was noted on any of the carbohydrates. The optimum temperature for growth was about 25° C. with no growth at 37° C. (Table 2). A hydrogen ion concentration of pH 6.5 proved most satisfactory with growth at pH 9.5 and as low as 5.85 but not lower (Table 2). Salt in concentrations as high as 18 and 20 per cent was tolerated in both solid and liquid media.

In order to correlate the findings in the laboratory with conditions in factory cheeses, hydrogen ion determinations together with salt determinations were made on cheeses in the factory varying in age from the new cheese to those ready for market.

METHODS

The method previously employed of sampling factory cheeses, varying in age by a day, was largely employed in the present studies. Where possible the same batch of cheeses were sampled from day to day.

In sampling the cheeses, the outer slimy surface was scraped off with a knife and labelled "A." After this five-sixteenth of an inch of cheese was cut off the outside and called sample "B." The next five-sixteenth of an inch was called "C" and the center "D." Salt, hydrogen ion and in some cases moisture determinations were made of these portions. At the same time bacterial samples were taken of the surface by bringing a glass slide in contact with the surface slime (1).

Hydrogen ion determinations were made with the quinhydrone electrode following the method of Sønke Knudsen as modified by Watson (4). Salt was determined in duplicate by the method recommended by Wilster *et al.* (5), for hard cheese. Though Limburger cheese is classed with the semisoft cheeses it is firm in the early stages and the method proved quite satisfactory.

In all, six lots of cheese were examined for hydrogen ion concentration and four lots for salt, covering periods of May, July, and October.

RESULTS

Hydrogen Ion Changes During Ripening

The pH dropped from about 6.45 in the milk at time of renneting to below 5.0 in the cheese within a few days (Tables 3, 4, 5 and Figure 1).

TABLE 3

Changes in hydrogen ion concentration of Limburger cheese made in May

Description of cheese	Age days	pH of surface	Microorganisms in surface smears
	2	5.64	Few bacteria and yeasts
	3	5.81	Yeasts increasing
	4	5.95	Yeasts in masses, a few rods
	5	6.57	Yeasts in masses, a few rods
First color	6	6.84	Yeasts in masses, a few rods
Good color	7	6.95	Yeasts in masses, a few rods
	8	7.56	Masses of yeasts and rods
	9	7.50	Masses of yeasts and rods
	10	7.75	Masses of rods, a few yeasts
Ready for storage	11	7.85	Masses of rods, a few yeasts

After the first or second day when the yeasts started to grow the pH of the surface slime was found to rise to around pH 7.0 or higher at about 7 to 12 days when the cheeses were ready to go to storage. Because of lower temperatures in the ripening room, the pH of the October cheeses did not go above 6.7 before being transferred to storage. The recorded figures in some cases may be somewhat low as difficulty was encountered in scraping off the slime without getting some of the interior of the cheese. This factor together with the gas in two cases would no doubt explain the irregularities of the points of the curves designated surface and 1st 5/16th in. (Figure 1). Little further change was noted in the pH of the surface up to the time the cheese was ready for market.

In the interior of the cheese (Samples B, C, and D) the rise in pH was not as rapid and hardly reached the neutral point at any time during ripening, being around pH 6.9 when ready for market. The rods (*Bacterium linens*) did not appear until the pH of the slime was around 5.85 and usually when it was higher. The red color appeared when the surface smear was somewhere about pH 6.8. When *Oospera* were found in any numbers in the surface smear or the cheese was gassy the pH was invariably lower than normal (Table 4, Figure 1).

The desirability of this first drop in pH, due no doubt to the growth of lactic acid streptococci, was shown in some work carried out on cheeses made at this same time from milk pasteurized at 143° F. for 30 minutes. Two lots of cheese were made with the milk as received and the pH did not drop below pH 6.0 (Table 6) followed by a steady rise in pH. When these cheeses were examined at a later date they were found to have a strong putrid odor. Another lot was made from milk of the same supply but 2 ml.

TABLE 4

Changes in hydrogen ion concentration of Limburger cheese made in July, 1937

Description of cheese	Age	pH in cheese				Microorganisms in surface smear
		Surface	First 5/16 inch	Second 5/16 inch	Center	
	1 day	4.95	4.90	4.80	4.65	A few rods evenly scattered
White slime	2 days	5.05	4.90	4.75	4.80	A few yeasts
	3 "	4.95	4.85	4.65	4.70	Fewer rods, yeasts well distributed
	4 "	6.05	5.20	4.70	4.70	Yeasts, some rods increasing
	6 "	6.45	5.45	4.75	4.60	Yeasts in masses, rods fewer
Gassy cheese	7 "	5.70	5.00	4.50	4.70	Yeasts more numerous, rods fewer
Good red color	8 "	7.00	5.70	4.80	4.70	Yeasts same, rods in masses
Gassy cheese	10 "	5.75	5.20	4.75	4.70	Yeasts fewer, rods fewer. *Oospera* present
	11 "	7.25	5.20	4.75	4.70	Yeasts few, rods in masses, a few *Oospera*
	12 "	7.35	5.35	4.85	4.70	Yeasts fewer and smaller, rods in masses
Ready for storage	13 "	7.40	5.60	4.80	4.65	Yeasts in masses but small, rods in masses
	4 weeks	7.35	5.35	4.85	4.70	Yeasts small, rods in masses
	5 "	7.35	6.00	5.45	4.90	No yeasts, rods in masses
	6 "	7.35	6.25	5.55	5.10	Yeast small and numerous, rods in masses
	7 "	7.25	7.00	6.05	5.55	Yeast small and few, rods in masses
Ready for market	8 "	7.45	6.25	6.05	5.80	Yeasts small and few, rods in masses

TABLE 5

Changes in hydrogen ion concentration of Limburger cheese made in October, 1937

Description of cheese	Age	pH in cheese[1]				Microorganisms in surface smear
		Surface	First 5/16 inch	Second 5/16 inch	Center	
	4 hours		5.65			
	6 "		5.33			
	1 day	4.37	4.37	4.30	4.25	Few bacteria and yeasts
	2 days	4.30	3.95	3.95	3.95	Yeasts increasing
	3 "	4.97	4.75	4.80	4.80	Yeasts the same
	3 "	4.82	4.70	4.70	4.70	Yeasts in masses
	4 "	4.70	4.55	4.25	4.50	Yeasts in masses
First red color	6 "	5.25	4.61	4.60	4.55	Yeasts and rods in masses and some *Oospera*
	7 "	5.20	4.90	4.65	4.50	Yeasts and rods in masses and some *Oospera*
	8 "	5.55	4.65	4.60	4.50	Yeasts and rods in masses and a few *Oospera*
	9 "	5.60	4.85	4.65	4.50	Yeasts and rods in masses and a few *Oospera*
	10 "	5.20	4.90	4.75	4.66	Yeasts and rods in masses and a few *Oospera*
	11 "	6.70	5.40	4.75	4.65	Yeasts and rods in masses
Ready for storage	12 "	6.55	5.10	4.60	4.60	Yeasts and rods in masses

The first 6 samples were from cheeses made October 4th. The remaining samples were from cheeses made October 1st.

[1] Cheese made from milk with pH 6.45 at the addition of rennet

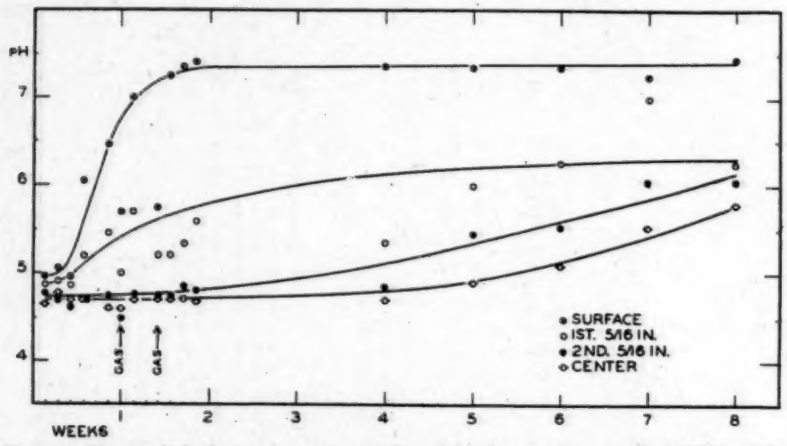

FIG. 1. Changes in hydrogen ion concentration of Limburger cheese made in July, 1937.

of starter were added for each gallon of milk at the time of renneting. By the third day the pH had dropped to 5.0 and though this drop was not as rapid or as low as in many commercial cheeses a typical Limburger developed with no sign of the putrefaction found in other cheeses. This development of acid appears to be necessary to control putrefying bacteria in Limburger cheese as in the hard pressed varieties.

Concentration of Salt in the Cheese

As would be expected and as shown by Mrozek (6), Byers and Price (7), and others the salt in the cheese was found in greatest concentration in the surface layers and lowest in the inner portions soon after salting (Tables 7, 8, and 9 and Figure 2). On the first day the percentage of salt was between 3.13 and 3.30 in the surface layer (Sample A), 2.03 to 3.04 in the second layer (Sample B), 0.36 in the next layer (Sample C) and 0.06 to 0.31 in the center (Sample D). From this time on the salt tended to diffuse

TABLE 6

Influence of added starter on hydrogen ion concentration and quality of Limburger cheese made from milk pasteurized at 145° F. for 30 minutes

	Age in days						
	½	1	2	3	4	6	7
	pH	*pH*	*pH*	*pH*	*pH*	*pH*	*pH*
No starter added. Cheese became putrid	6.0	6.15	6.30		6.30	6.30	
No starter added. Cheese became putrid	6.25		6.15		6.65		
Starter added. Good cheese	6.15		5.55	5.00			6.00

through the cheese until an equilibrium was reached near the tenth day when the percentage was about the same throughout the cheese. Considering that the method of salting is by rolling the cheese in the salt and rubbing with the hands it is surprising to find the salt content from cheese to cheese as uniform as it is. Though moisture should have been taken into consideration in reporting the salt content it was difficult to obtain satisfactory samples. However when corrections were made using the moisture determinations that were made the variations in salt content were so small as not to change greatly the relationship of the amounts as given (Tables 7, 8, and 9 and Figure 2).

TABLE 7

Changes in salt content of Limburger cheese made during July, 1937

Age	Surface	First 5/16 inch	Second 5/16 inch	Center
1 day	3.28	3.04	0.63	0.31
2 days	3.12	2.71	1.15	0.61
3 "	2.33	2.33	1.64	0.80
4 "	1.56	2.31	1.60	0.93
6 "	2.33	2.34	2.00	1.56
7 "	2.38	2.23	1.68	0.91
8 "	1.55	2.05	1.71	1.41
10 "	2.10	2.23	2.21	1.71
11 "	1.69	1.85	2.13	2.10
12 "	2.56	2.46	2.53	2.40
13 "	2.00	2.53	2.36	2.13
4 weeks	1.49	1.69	2.03	1.76
5 "	1.46	1.80	1.78	1.73
6 "	1.46	1.70	1.80	1.90
7 "	1.81	1.88	1.80	1.70
8 "	1.88	1.96	2.11	2.09

TABLE 8

Changes in salt content of Limburger cheese made during October, 1937

Age days	Surface	First 5/16 inch	Second 5/16 inch	Center
1	3.13	2.03	0.90	0.30
2	2.15	1.20	0.88	0.55
4	2.03	1.90	1.40	1.26
5	1.76	1.73	1.73	1.50
7	1.66	1.96	1.86	1.56
9	1.64	1.68	1.48	1.42
11	1.46	1.43	1.53	1.46
12	1.66	1.56	1.66	1.43

In determining the influence of salt on the growth of bacteria in cheese several factors must be taken into consideration in estimating the concentration of salt in contact with the organisms. It is to be expected that most of the salt would be dissolved in the moisture of the cheese and because of this the percentage of salt as determined by an analysis of the cheese does

TABLE 9

Changes in salt content of Limburger cheese made during October, 1937

Age days	Per cent of salt			
	Surface	First 5/16 inch	Second 5/16 inch	Center
1	3.30	2.86	0.36	0.06
2	2.26	2.13	1.50	0.36
3	2.30	2.23	1.86	0.76
3	2.13	1.82	1.44	1.02
4	1.80	1.76	1.50	1.03
5	1.60	1.46	1.70	1.06
6	1.53	1.56	1.54	1.15
7		1.76	1.60	1.50
8		1.76	1.60	1.46
9		1.73	1.60	1.53
10		1.76	1.63	1.46
11		1.76	1.60	1.56
12		1.76	1.63	1.53

not give a true picture of conditions in the cheese. Therefore in estimating the salt content of the medium in which the bacteria are growing the moisture content of the cheese must be taken into consideration. The moisture content of the surface layer varied from 40 to 42 per cent and from 42.5 to 44 per cent in the center portion. Assuming that all the salt is in solution in the cheese moisture, this brine in the surface layer of a one-day-old cheese

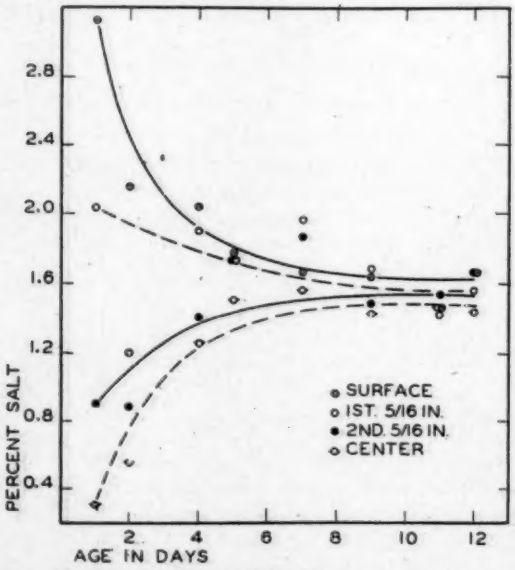

FIG. 2. Changes in concentration of salt in Limburger cheese.

(Table 9) with 41 per cent moisture would have 8.0 instead of 3.3 per cent salt. At 2 days the per cent of salt would be 5.5 instead of 2.26 and at 5 days 3.9 instead of 1.6 per cent.

McDowall and Dolby (8), working with Cheddar cheese, came to the conclusion that a large part of the cheese moisture was not free moisture though they were unable to make conclusive tests. However they estimated that 20 to 30 per cent of the moisture in a young cheese was bound. Assuming that 30 per cent of the moisture is bound, the concentration of salt in the free water would be 11.4 per cent in the surface layer of a day-old cheese. The surface layer of the 2-day-old cheese would then have a salt content of 7.8 per cent and the cheese at 5 days, 5.5 per cent. These theoretical considerations establish that the salt concentration of the cheeses a few days after salting would in no way retard the growth of the organisms desired.

A short time after the cheese is salted, on the evening of the day when made and the morning of the following day, the salt content of the brine in the surface layer must be near the saturation point as there is a considerable amount of undissolved salt present. Therefore for at least some hours after salting the cheese, only salt tolerant organisms would multiply. This is given support in the work of Macy and Erekson (2) where it was shown that *Streptococcus lactis* disappeared when the cheese was salted and yeasts took their place.

DISCUSSION

During making and the early stages of ripening the rapid fall in pH is undoubtedly largely due to the action of lactic acid streptococci. The pH which falls lower than in normal Cheddar cheese is no doubt due to a higher moisture content in the Limburger cheese with more lactose to be converted to lactic acid. This lowering of the pH is desirable in making Limburger cheese in that it keeps putrefying bacteria from growing.

The high concentration of salt on the surface suppresses the many miscellaneous organisms found on the new cheese and permits the development of the yeasts that can grow at a low pH. The yeasts by acting on both the lactate and the protein soon raise the pH above the point (pH 5.85) where *Bacterium linens* can start growth. Other organisms that might grow at this pH are suppressed by the concentration of salt while *Bacterium linens* grows readily. At this point the yeasts have completed their work and soon die out, being overgrown by *Bacterium linens*. Acting on the protein *Bacterium linens* raises the pH still higher and is believed to complete the ripening of the cheese. The cheeses become inoculated with both organisms from the ripening shelves, which in the factory are heavily seeded with the organisms.

Though no work as yet has been carried out on the internal flora of the cheese it does not seem probable that *Bacterium linens* would be a factor

because of its aerobic nature and its inability to grow at a pH lower than 5.85. This tends to strengthen the theory that the soft buttery texture and a part of the flavor is produced by the action of enzymes of *Bacterium linens* rather than by direct action of the organism itself. The question whether the enzymes penetrate the cheese and digest proteins could best be established by a study of the enzymes.

SUMMARY

The yeast forms first appearing on the surface of Limburger cheeses will grow readily on artificial media between pH 3.5 and 8.5 and with the best growth at pH 6.5.

Bacterium linens will not grow below pH 5.85 but will grow at pH 9.5 and grows best at pH 6.5.

In the cheese the pH of the surface falls to 5.0 or lower, a pH at which the yeast will grow but not *Bacterium linens*. The yeasts acting on both the protein and lactic acid, raise the pH above 5.85 at which point *Bacterium linens* can become established and overgrow the yeast. Only late in the period of ripening does the pH of the interior of the cheese rise above 5.85. This pH and the lack of oxygen would inhibit the growth of *Bacterium linens* in any part of the cheese excepting the surface.

The concentration of salt soon after salting is highest in the surface layer and low in the interior. There is a gradual penetration of salt into the cheese until an equilibrium is reached at about 10 days. With the lack of information on how much of the moisture of the cheese is available to form brine it is impossible to estimate accurately the concentration of salt in the medium in which the bacteria are growing. However, as the cheeses are salted by rubbing salt on the outside there is little doubt but that it is near the saturation point in the surface layer for some time. This high concentration of salt tends to inhibit the growth of organisms other than the yeasts and *Bacterium linens*.

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CAROTENE IN THE NUTRITION OF DAIRY CALVES*

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The necessity of vitamin A for proper growth and well being of dairy calves has been conceded quite generally for the past ten years. It has been shown that for this species the general symptoms of vitamin A deficiency are slow growth, general unthriftiness, scours, blindness, susceptibility to pneumonia, and oedema.

Studies at the Pennsylvania Agricultural Experiment Station in which large amounts of cottonseed meal were fed to calves have shown definitely that supplements of cod liver oil or alfalfa hay of good quality will prevent the usual malnutrition or cottonseed meal injury that results from such feeding practice. If the injury had not progressed too far cures were affected by the same treatment. The vitamin A present in the cod liver oil and the carotene (the mother substance of vitamin A) in alfalfa undoubtedly played a major rôle in the prevention and cure of this malnutrition. Carotene dissolved in cottonseed oil, on the other hand, apparently had little or no effect in the prevention or cure of this nutritional ailment.

Jones, Eckles and Palmer (11) showed very conclusively that vitamin A is indispensable in the growth of dairy calves. Bechdel, Eckles and Palmer (3) in the same year reported that calves developed symptoms of vitamin A deficiency when cod liver oil was not included in their experimental ration of corn gluten feed, casein, polished rice and butterfat.

Converse and Meigs (6) found that cows fed on timothy hay of low grade for a period of two or more years were unable to produce normal calves. Calves fed on the milk from these cows soon died. The investigators found that vitamin A in the form of carotene or cod liver oil can be added to the deficient milk rations of the calves and by doing so make them adequate for producing approximately normal growth.

After depleting calves of their body store of vitamin A by feeding a basal diet composed of skimmilk, cottonseed meal, dried beet pulp and bone meal, Kuhlman, Gallup and Weaver (12) found that 5 ml. of a commercial carotene preparation fed in combination with a vitamin D supplement was as effective in relieving the vitamin A deficiency symptoms as 30 ml. of cod liver oil.

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Bechdel (2), and Bechdel, Williams and Skaggs (4) produced typical cottonseed meal injury in calves. The symptoms simulated vitamin A deficiency, only the injury seemed to be somewhat more severe in that occasional cases of convulsions were observed. Cod liver oil gave adequate protection against the injury and brought about rapid recovery, while carotene seemed to be less effective in protecting against the cottonseed meal injury.

Hart and Guilbert (9) observed vitamin A deficiency in cattle under range conditions. They report (10) that about twenty-nine micrograms of carotene in alfalfa hay per day per kilogram of body weight would prevent or cure vitamin A deficiency symptoms in cattle.

Investigators have shown that the type of solvent used is an important factor in determining the biological value of carotene. According to Dutcher, Harris, Hartzler and Guerrant (7) carotene dissolved in mineral oil cannot be utilized by the rat.

Moore, Huffman and Duncan (14) observed blindness in calves dropped by cows while receiving roughage of poor quality. These investigators observed a similar condition among growing heifers fed the same type of ration. Kuhlman, Gallup and Weaver (13) reported two types of blindness among calves which may be related to vitamin A deficiency.

EXPERIMENT I

Grade Holstein calves were used as experimental subjects. The concentrate mixture fed was similar to calf rations commonly used on good dairy farms. In order to keep the vitamin A potency of the ration quite low, yellow corn was not included in the mixture. The constituents were as follows:

Wheat bran	150 pounds
Oat mids	200 pounds
Hominy feed	300 pounds
Linseed meal	100 pounds
Distillers' grain	50 pounds
Irradiated yeast	1 pound
Salt	2 pounds

The treatment of the calves previous to going on experiment consisted in feeding them whole milk until twenty days of age. At this time the whole milk was gradually replaced with skimmilk which was fed to all calves continuously while on experiment. Timothy hay of very low grade, almost devoid of green color, was fed prior to as well as in the experimental period. The skimmilk was produced by cows fed on a low vitamin A diet.

All animals were put on the basal ration at the beginning of the experiment, and no change was made until symptoms of vitamin A deficiency were observed. The symptoms first noticed were loss of appetite and scouring. This was followed by a general drop in body weight and blindness developed

in two of the five animals used. The weight of the animal was the main criterion used in determining when to start supplementing the ration with the treatment.

A preparation of carotene dissolved in cottonseed oil was used as the source of vitamin A for two animals (calves 338 and 340). This preparation contained approximately 3,000 U.S.P. units of vitamin A activity per gram. The amounts of this supplement fed are given in Figure 1. It was

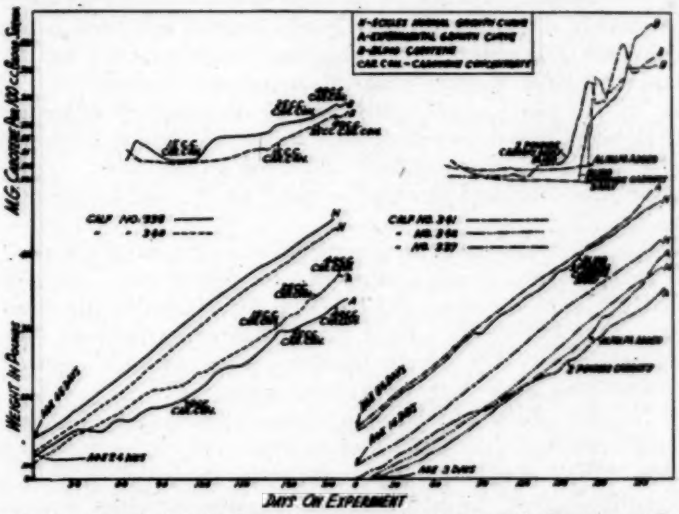

FIG. 1. Growth and blood carotene curves of calves used in Experiment I.

fed daily by adding it to the skimmilk just before feeding. Two animals (calves 337 and 341) were fed two pounds of fresh carrots daily containing approximately 30,000 vitamin A units. Dehydrated alfalfa hay of good quality was fed to one calf (calf 342).

Carotene content of the blood serum was determined at regular intervals throughout the experimental period. The Palmer method modified by Conner (5), and White and Gordon (15) was used. Non-protein nitrogen, glucose and hemoglobin were determined on the blood of each animal at regular intervals.

RESULTS ON INDIVIDUAL CALVES

After the animals were depleted of their vitamin A reserve they were treated as individuals and no effort was made to experiment with them as groups or pairs.

The treatment and response of each animal is portrayed in Figure 1. The Eckles normal growth curve is used as a standard for growth.

Calf No. 338 which had received the carotene concentrate made normal

growth for only the first 30 days on the experimental ration. It developed pneumonia on the 44th day and from that date on showed typical symptoms of vitamin A deficiency. Carotene supplement in large doses was administered on the 109th day and continued until the end of the experiment. This amount of carotene was effective in increasing the blood carotene slightly but the animal's growth rate gradually declined.

Calf No. 340 which also received the carotene concentrate made normal growth on the experimental ration for the first 85 days when typical symptoms of vitamin A deficiency, scours, loss of appetite and nasal discharges appeared. The administration of the carotene supplement did not increase the blood carotene or the growth rate to an appreciable extent.

Calf No. 337 made normal growth on the experimental ration for the first 81 days. It showed typical vitamin A deficiency symptoms, consisting of scours, loss of appetite and finally blindness on the 164th day. When carrots were fed, the blood carotene increased rapidly and the growth rate was accelerated.

Calf No. 341 was below normal in weight when put on experiment. Its growth rate remained almost constant for the first 80 days, but declined appreciably from this time on until 156 days on experiment. Blindness was observed on the 142nd day. About one week after carrots were added to the ration the growth rate began to increase. A phenomenal increase of the blood carotene was also observed after carrots were fed.

Calf No. 342 made practically normal growth gains although she showed symptoms of vitamin A deficiency such as scours, loss of appetite and nasal discharges. The addition of alfalfa to the ration increased the blood carotene immediately, and the rate of growth was also increased remarkably. Other symptoms of vitamin A deficiency also disappeared promptly.

GENERAL DISCUSSION

The results with calves Nos. 338 and 340 indicate that carotene dissolved in cottonseed oil is not utilized to the extent that it will prevent or cure avitaminosis A that results from feeding the above experimental rations. There is evidence that the calves utilized some of the carotene but not enough to make its effect significant.

Carrots were quite effective in correcting the avitaminosis A (blindness excepted) in calves Nos. 337 and 341. Alfalfa hay of good quality (dehydrated) appeared to be slightly more effective than carrots as shown by the results on calf No. 342. This is explainable through the fact that the alfalfa was fed in relatively large amounts and, therefore, more vitamin A units were supplied than in the carrots fed to the calves Nos. 337 and 341.

The blood carotene studies are of special interest in this connection. The chart reveals that the carotene appeared in the blood stream almost immediately in large amounts when carrots or alfalfa were fed to the

calves suffering from avitaminosis A. The blood carotene was increased in amounts that were barely measurable when a carotene supplement was fed to the calves suffering with avitaminosis A. It is interesting to note, as indicated in the chart, that the potential units of vitamin A in the carotene supplement administered were much greater than the total unitage contained in the carrots.

Non-protein nitrogen, hemoglobin, and sugar determinations made during the depletion period did not show abnormal values as found by Anderson, Gayley and Pratt (1).

EXPERIMENT II

A second experiment was planned with the view of obtaining further information on the effectiveness of carotene in preventing and in curing the usual avitaminosis A that occurs from feeding calves on hay of poor quality. Timothy hay of low grade (with little green color) was used in this experiment. Six calves (calves 354, 356, 357, 361, 362, and 363) were fed a concentrate ration low in vitamin A. This grain ration was very similar to rations commonly used by dairy farmers. Five other calves (calves 349, 350, 355, 364, and 365) were fed a grain ration which contained fifty-seven per cent cottonseed meal. Two of these calves (calves 364 and 365) received no hay. All calves were left with their dams for two or three days after birth. They were then fed whole milk until two weeks of age, after which skimmilk was gradually substituted for the whole milk. All calves were weighed at weekly intervals at which time blood samples were taken for carotene determinations.

The timothy hay, assayed by the colorimetric method, was found to contain 4.5 micrograms of carotene per gram. The carotene supplement was guaranteed to have a biological activity of approximately 3,000 U.S.P. units of vitamin A per gram. This concentrate was weighed into $\frac{1}{4}$ and $\frac{1}{2}$ ounce capsules and administered by means of a balling gun. The livers of all calves that were slaughtered were assayed for vitamin A by the antimony trichloride method as outlined by Guilbert and Hart (8).

One of the calves (calf 362) receiving the low vitamin A ration was fed four and one-half grams of the carotene supplement beginning with the sixth week and continuing to the end of the experiment. The five other calves were fed the basal ration until marked symptoms of vitamin A deficiency occurred. At this time amounts ranging from four and one-half to eighteen grams of the carotene supplement were administered daily to the different individuals (Figure 2). Three of the calves (calves 349, 350, and 355) receiving the high cottonseed meal ration were treated in a like manner. One of the two calves (calf 364) receiving no hay was given four and one-half grams of the carotene supplement daily. The other calf (calf 365) was continued on the basal ration until it became very weak. Nine grams of the carotene supplement were then administered to this animal daily. Here

again, the chief criterion for starting the administration of carotene supplement was failure of the animal to gain in weight. Other symptoms of vitamin A deficiency, especially dilated pupils and blindness, were used as further means of diagnosis.

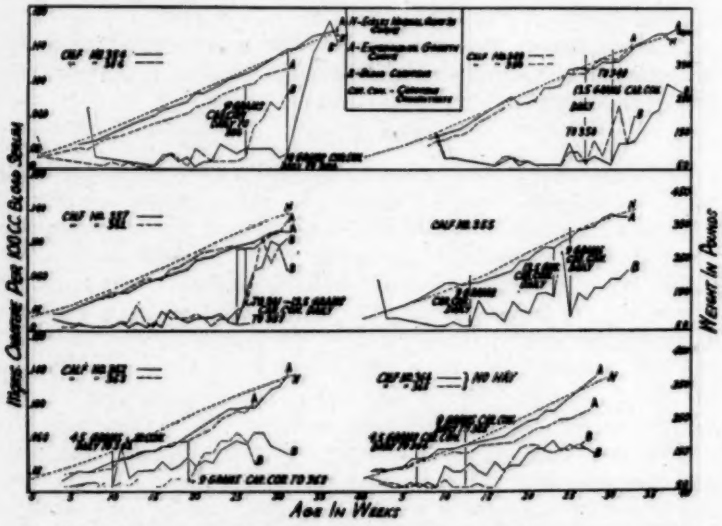

FIG. 2. Growth and blood carotene curves of calves used in second experiment.

RESULTS AND DISCUSSION

In every case following the administration of the carotene concentrate there was a marked improvement in general condition of the calf which also was usually accompanied by an accelerated growth rate. The effect of carotene administration on blood carotene varied from slight increases in some cases to very decided increases in other cases (Figure 2). The increases observed correspond roughly with the quantity of carotene administered. The relative amounts of vitamin A in the liver tissues also were found to correspond closely with the quantity of carotene supplement administered. This fact offers further proof that the carotene supplement was being utilized by the calves as a source of vitamin A.

The calves fed on the high cottonseed meal ration (calves 349, 350, 355, 364, and 365) exhibited symptoms which corresponded closely with the symptoms exhibited by those on the low vitamin A ration without cottonseed meal. They responded to the administration of the carotene concentrate in the usual manner. The calves on this ration showed a greater tendency toward intestinal disturbances and they also exhibited symptoms of

vitamin A deficiency in a much shorter time than did similar calves receiving the other low vitamin A ration which contained no cottonseed meal.

The poor response of calf No. 365 while receiving no hay indicates the importance of hay as a source of carotene in the nutrition of calves. In this case distinct symptoms of malnutrition were produced very readily in the absence of both hay and carotene from its ration. Following the administration of 9 grams of the carotene supplement daily this animal showed marked improvement but never became normal. On the other hand, four and one-half grams of the carotene supplement when added to the ration of calf No. 364, was sufficient to prevent malnutrition in this animal for a considerable period (Figure 2).

Blindness was not observed in those calves in which severe avitaminosis A appeared quite rapidly. It appeared, however, in cases of those which had undergone a prolonged period of mild avitaminosis A during which the growth rate was only slightly subnormal. By carefully examining the eyes of the animals, it was found that the pupils were always dilated, and that the onset of blindness could be detected.

The carotene supplement used in this experiment, when administered in capsules and used in combination with a ration which was adequate in other respects, appeared to give results which compare very favorably with the results that had been obtained previously with alfalfa, carrots, and cod liver oil. The more clear cut and significant responses obtained in the second experiment as the result of feeding vitamin A deficient calves definite amounts of the carotene concentrate are in all probability due to improvements in technic and to more extensive data obtained through the use of a larger number of animals.

SUMMARY

Avitaminosis A was produced in growing calves through the use of poor quality bleached and aged timothy hays fed in connection with a grain mixture. Fresh carrots and alfalfa hay (dehydrated) of good quality were quite effective in correcting this avitaminosis A in calves. A commercial carotene concentrate also proved effective in preventing and curing the avitaminosis A that resulted from feeding calves rations of low carotene content, as well as overcoming the malnutrition resulting from feeding high percentages of cottonseed meal.

ACKNOWLEDGMENT

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THE REPRODUCTIVE EFFICIENCY OF DAIRY CATTLE*

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High reproductive efficiency in livestock is economically a very desirable characteristic. The frequency of calving determines to a great extent the amount of milk a dairy cow produces during her lifetime. A review of literature reveals different methods of measuring the reproductive powers of dairy cattle.

Williams (1) recognized the economic and scientific importance of the application of some intelligible standard of breeding efficiency. He adopted two years as the ideal age at which a heifer should calve, which necessitates conception at fifteen months. Every calendar month after the fifteenth was designated as a "breeding month." Twelve months was considered as an ideal calving interval. He determined the average number of breeding months required to produce a calf by dividing the total breeding months by the number of calves born. The percentage reproductive efficiency was obtained by dividing twelve, the ideal number of breeding months for the production of a calf, by the determined average number of breeding months per calf. Williams (2) reported on a Guernsey herd which produced a calf for each 28.7 breeding months, or 41.8 per cent of ideal efficiency.

Käb (3) studied the breeding records of 1475 cows, 136 bulls and 7104 calves of the Yellow Franconian breed of dairy cattle. "An analysis of the fertility of the daughters of 22 bulls revealed considerable variation between the various families which indicated a genetic basis. Through several generations 35 families showed high fertility and 11 families low fertility."

The number of services per pregnancy and percentage of conceptions are frequently employed when measuring the breeding ability of dairy cattle (4) (5). These measures do not take into consideration the fact that many cows fail to show oestrus regularly, thereby lowering their reproductive efficiency, but not necessarily affecting the services per pregnancy. In such a calculation heifers that never calve are naturally omitted from the records. A mediocre individual might be disposed of as sterile after three or four services, whereas a more valuable animal might be given more consideration and conceive to a later service.

PLAN OF STUDY AND PROCEDURE

The study to be reported in this paper was undertaken to determine the reproductive efficiency of groups of dairy cows descended from different foundation cows. The data available for the study consist of the individual

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breeding records of 368 cows in the dairy herd owned by the Oregon State Agricultural College. Four of the major breeds of dairy cattle are represented. The records cover the period beginning with the purchase of the foundation cows in 1913 and up to 1938.

The management policies have been substantially uniform for all groups of cows. All the dairy cattle were housed and fed in the same barn, with no attempt to segregate the various breeds or groups.

Undoubtedly the most important disease factor which could affect a problem of this kind is Bang's disease. The Veterinary Department of the College began testing the College dairy herd for Bang's disease in 1919, and has continued to test at regular intervals since that time. In the fall of 1922, all of the animals which reacted to the agglutination test for Bang's disease were removed from the College dairy herd. Since that time there have been occasional removals of suspect or reactor animals. It is unlikely that any one group or breed of dairy cows intermingling freely in a herd would be more susceptible than others to an infectious disease affecting reproductive efficiency. An analysis of the groups and breeds of cows in the herd being studied shows this to be true.

The term reproductive efficiency is proposed as a measure of the net biological accomplishment of all reproductive activity. It represents the integrated effect of all the factors concerned, *i.e.*, oestrus, ovulation, fertilization, implantation, gestation, and parturition.

The numerical expression of reproductive efficiency is based on the assumption that to be 100 per cent efficient, a heifer should be bred at a certain age depending upon the breed, and that she should drop a calf every twelve months thereafter. The total number of reproductive months represent the number of months that an animal remained in the breeding herd.

As 12 months is assumed to be the desired calving interval, it follows that each cow should be credited with 12, 100 per cent months per pregnancy. Thus for convenience in obtaining a numerical expression of reproductive efficiency and for want of a better term, each month of the calving interval has been designated as one 100 per cent month. That portion of the calving interval in excess of 12 months is considered as possessing 0 per cent reproductive efficiency. Any cow known to be pregnant which was removed from the herd before calving was allowed one 100 per cent month for each month of pregnancy. *The number of 100 per cent months divided by the total number of reproductive months gives the per cent reproductive efficiency.* In the measure of reproductive efficiency proposed by Williams (1) incomplete reproductive cycles were not evaluated and heifers that never calved were not considered.

For the purpose of this study each individual foundation cow and her female descendants retained in the College herd composed a cow group. Each breed was divided into its component cow groups. The groups include from four to eleven generations and contained from 11 to 62 cows with breeding

records. Heifers sold for reasons other than sterility or difficult breeding before the completion of at least one pregnancy were not included in this study.

The per cent reproductive efficiency was determined for each cow. The mean per cent reproductive efficiency with its probable error was determined for each cow group having 11 or more individuals with breeding records. Bessel's formula (6) for the application of probability to small samples was used. To determine if the differences between the various cow groups and breeds were significant, the odds against such a difference occurring due to chance were calculated. Odds of 30 : 1 or greater were considered significant.

RESULTS OF STUDY

Reproductive Efficiency of Cow Groups

In breed No. 1 foundation cows A_2, A_3, A_4 were daughters of A. In breed No. 2, foundation cow E_1 was a daughter of E, and in breed No. 3 foundation cow H_1 was a daughter of H. Since, all these cows were purchased as foundation animals the female descendants of each were considered as composing a cow group. This treatment results in duplication in the above indicated groups.

Breed No. 1. As shown in Table 1, breed No. 1 contains seven cow groups

TABLE 1

Reproductive efficiency of cow groups

Cow group	Females with herd number	Cows with breeding record	Reproductive months	100 per cent months	Mean reproductive efficiency
	No.	No.	No.	No.	%
Breed No. 1					
A	97	62	3264	2463	67.24 ± 2.51
A_2	38	25	1241	926	63.74 ± 4.68
A_3	38	22	1138	889	71.33 ± 3.55
A_4	18	12	619	468	70.57 ± 5.60
B	15	11	776	672	85.48 ± 2.44
C	13	12	709	396	54.46 ± 4.83
D	16	14	863	624	70.02 ± 4.85
Breed No. 2					
E	58	39	2032	1576	79.35 ± 1.29
E_1	49	31	2104	1519	81.86 ± 1.88
F	50	37	1574	1252	79.24 ± 2.15
G	20	14	753	571	68.83 ± 5.28
Breed No. 3					
H	71	40	2419	2037	81.90 ± 1.92
H_1	32	19	1098	999	87.22 ± 1.62
I	94	52	2851	2428	84.38 ± 1.19
J	30	16	1003	835	79.72 ± 4.46
K	19	13	653	469	68.41 ± 5.10
Breed No. 4					
L	21	11	608	477	81.97 ± 1.06

of 11 to 62 animals with breeding records. The mean per cent reproductive efficiency for the various cow groups ranged from 54.46 ± 4.83 to 85.48 ± 2.44, a difference of 31.02 ± 5.4. The odds against such a difference occurring due to chance are 6249 : 1. The foundation cows of groups A_2, A_3, A_4 were full sisters. The foundation cows of groups B, C and D were not related.

Breed No. 2. Four cow groups in Breed No. 2 contain from 14 to 39 animals with breeding records. Group E_1 has the highest mean reproductive efficiency with 81.86 ± 1.88. Group G has the lowest with 68.83 ± 5.28. The difference of 14.03 ± 5.6 with odds of 9 : 1 may not be significant.

Breed No. 3. The number of cows with breeding records in five of the cow groups of Breed No. 3 ranged from 13 to 52. The difference in reproductive efficiency between the high group H_1 and the low group K is 18.81 ± 5.35. The odds against such a difference occurring due to chance are 54 : 1.

Breed No. 4. Breed No. 4 contains one cow group of 11 or more cows with breeding records. Group L with 11 cows has a mean reproductive efficiency of 81.97 ± 1.06 per cent.

Composite Reproductive Efficiency

It will be recalled that in studying the cow groups only those groups with 11 or more cows with breeding records were considered. However, in compiling the data presented in Tables 2 and 3 dealing with the reproductive efficiency of the entire herd, all cows with reproduction records were included. This difference in procedure explains what might appear to be a discrepancy in the number of animals considered in Table 1, as compared to the numbers in Tables 2 and 3. Duplication of cows are also eliminated in Tables 2 and 3.

TABLE 2

Reproductive efficiency of herd

Breed	Females with herd number	Cows with breeding record	Reproductive months	100 per cent months	Mean reproductive efficiency
	No.	No.	No.	No.	%
1	143	99	5612	4156	67.55 ± 1.88
2	153	106	5549	4215	75.44 ± 1.47
3	214	121	6926	5769	81.27 ± 1.67
4	71	42	2269	1648	72.77 ± 1.51

Breed No. 1 has the lowest mean per cent reproductive efficiency with 67.55 ± 1.88, and breed No. 3 the highest with 81.27 ± 1.67. The difference of 13.72 ± 2.51 appears significant, with the odds of 3571 : 1 against such a difference occurring due to chance. This difference must, however, be taken to apply to the particular herd studied, rather than to breeds at large.

Table 3 shows the manner in which the individual cows were distributed with respect to reproductive efficiency.

TABLE 3

Distribution of reproductive efficiency of all cows studied

Class rep. effi.	0 %	1–20%	21–40%	41–60%	61–80%	81–100%
Breed	% of all animals of each breed					
1	9.6	0	8.6	12.4	34.6	34.5
2	3.6	0	0.9	10.9	36.6	47.6
3	2.3	0	0	8.5	27.0	61.9
4	0	0	2.3	23.2	34.8	39.5
Herd	4.42	0	2.85	11.95	32.73	48.05

This treatment of the results strengthens the contention that the cow groups in this study possess significant differences in reproductive efficiency.

DISCUSSION

It is realized that in a study of this type some assumptions are necessary, and it is impossible to eliminate all factors that may affect the results obtained. Apart from the procedure and numerical method of expressing reproductive efficiency two questions arise which have important bearing on the validity of the conclusions arrived at.

One question is the number of animals necessary for such a study. In comparing cow groups within the breeds only those with 11 or more cows with individual breeding records have been considered. Inasmuch as this study involves the reproductive performance of 368 animals it is felt that the results should possess a fair degree of reliability.

One of the most difficult problems in a study of this sort is to assess the influence of the herd sire. It is not to be inferred that the impaired reproductive efficiency encountered in this analysis was not in part due to the sires. Since, however, this study extended over a period of 24 years and involved some 21 bulls for breed No. 1, 17 bulls for breed No. 2, 10 bulls for breed No. 3, and 16 bulls for breed No. 4, obtained from widely different sources and largely unrelated, it does not appear likely that the influence of any sires of low fertility was concentrated in any one breed or group. This is strengthened by the fact that widely different efficiencies were obtained with substantially the same sires. For example, in breed No. 1, cow group C shows a very low mean reproductive efficiency, while cow group B shows a very high mean reproductive efficiency.

Another method of approach which indicates that the difference in reproductive efficiency between cow groups is significant, deals with the correlation between the reproductive efficiency of the foundation cows of the groups studied and the mean reproductive efficiency of their female descendants. The value obtained for this correlation was $r = +.546 \pm .118$. Although the number of animals considered in this correlation is limited it appears that the importance of selecting foundation cows with high reproductive efficiency should be strongly emphasized.

SUMMARY

1. A numerical method of measuring the reproductive efficiency of dairy cattle has been suggested.

2. This measure has been applied to the breeding records of the herd of dairy cows owned by the Oregon State Agricultural College during a 24 year period.

3. In the herd studied a marked difference in reproductive efficiency between various cow groups and between breeds has been noted.

4. A correlation of $r = +.546 \pm .118$ was found to exist between the reproductive efficiency of the foundation cows and the mean reproductive efficiency of their respective female descendants.

5. The study suggests that the reproductive efficiency of the foundation cow is an important factor in determining the mean reproductive efficiency of her offspring.

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A NOTE ON THE SUITABILITY OF VARIOUS LOTS OF DYE FOR USE IN THE RESAZURIN REDUCTION TEST[1]

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Most of the studies reported in the literature on the use of the resazurin reduction test for grading milk and other fluid dairy products seem to have been made using dye obtained from one manufacturer. Although other brands have been available, they apparently have not been used by dairy sanitarians in this country. When using one of these other brands of dye, the author obtained results less satisfactory than those reported in the literature. This led to comparisons of four different brands of resazurin. The brands were designated A, B, C and D, and each was obtained in the original package of the manufacturer whose label it bore. The comparative tests were made using Ramsdell's procedure (1) on samples of aseptically drawn and market milks. Some of the tests were made within an hour or two after the samples had been taken, the samples being held in ice during the interim. The other tests were made on samples which had been held overnight at 3–5° C. All tests were observed at hourly intervals for at least five hours. The colors of the dye in acid and alkaline solution were obtained by adding excesses of dilute hydrochloric acid and sodium hydroxide, respectively, to the stock solutions.

The results of the comparisons of the different brands of dye are shown in Table 1. Brand A is the one which has been used in most studies of the resazurin test. The lot of this dye which was used underwent the "normal" sequence of color changes and was used as a standard of comparison. Brand D also gave satisfactory results in the test. In the two instances in which results with brand D were not identical with those obtained using brand A, the more rapid color change undergone by brand D was slight but of sufficient magnitude to be observed easily. Brands B and C were entirely unsuited for use in the resazurin reduction test, the only change in color, that to the completely reduced form, occurring too slowly to be of practical use.

Of the four brands of resazurin examined, only two, A and D, were satisfactory for use in the resazurin reduction test as applied to milk. The exact nature of the differences between the four lots of dye was not determined. If the resazurin test is to be adopted generally, the need of standardization of the dye and of certification of different lots of dye by a responsible agency is definitely indicated.

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TABLE 1

Comparisons of characteristics of different brands of resazurin for use in the resazurin reduction test

Brand	Solution characteristics					Results of use in reduction test	
	Ease of solution*	pH of stock solution	Color of stock solution	Color in acid solution	Color in alkaline solution	Color change in milk	Results obtained
A	Easily soluble	7.55	Purplish blue	Pinkish rose changing to moderate orange	Clear blue	Blue→lavenders →pink→colorless	Satisfactory
B	Slowly and incompletely soluble	.....	Muddy blue	Muddy blue	Muddy blue	Muddy blue→colorless	Unsatisfactory. Color change occurs at about time of pink→colorless change of brand A
C	Almost insoluble in water. Incompletely soluble after addition of alkali to pH 7.88	7.88	Purplish rose, resembling colloidal gold sol.	Moderate orange	Clear blue	Pink→colorless	Unsatisfactory. Color change parallels last change of brand A
D	Easily soluble	7.60	Purplish blue	Pinkish rose changing to moderate orange	Clear blue	Blue→lavenders →pink→colorless	Satisfactory. Same results as with brand A in all but 2 of 102 comparisons

* 0.05% dye in distilled water.

THE RELATIONSHIP BETWEEN FAT CONTENT OF FRESH MILK AND ITS APPARENT ACIDITY

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For a great number of years the titratable acidity test for acid in milk has been used as a means of measuring the quality of milk for condensing, evaporating, drying, and for other general uses. It has long been known by scientists and creamerymen that fresh raw milk which contains no lactic acid will test from .07 to .28 per cent "lactic" acid as measured by this test. This test was first adopted because of the fact that high-acid milk generally has a low heat coagulation point. The revelations of more recent investigations (1) have shown that the titratable acidity is not the only, and in many instances, not the dominating factor determining the behavior of milk toward the manufacturing process.

It has also been shown that the apparent acidity has no effect on the heat coagulation point of milk (2) and should, therefore, have no part in the determination of the fitness of milk for condensery purposes, that the natural acidity constitutes a large part of the titratable acidity in milk when it is delivered to the processor and may in some rare instances even be above the limit of acidity set for acceptable milk, (3) and that, therefore, the titratable acidity is not an accurate index to the fitness of milk for manufacturing (4).

Due to the many shortcomings of the titratable acidity test, scientists have set forth in an earnest endeavor to discover or devise a more suitable test for measuring the true fitness of milk for manufacturing. The pH test for hydrogen-ion concentration in milk has been suggested, the alcohol test has been used to a considerable extent, the phosphatase test has been used as a supplementary test and many other tests have been used. These tests are all deficient, however, in requiring more skill in operation, more equipment, and more time and their value is questionable in many instances.

L. A. Rogers and his co-workers, (1) in their study of the relation of acidity to the coagulation temperature of evaporated milk, say that notwithstanding the generally accepted views as to the usefulness of grading milk on the basis of titratable acidity, the results obtained by determining the hydrogen-ion concentration electrometrically do not indicate that the relation between the acidity of fresh milk and the coagulating point after evaporation is sufficiently uniform to be of much value in grading milk. This is evident, they further say, because the hydrogen-ion concentration that gives maximum stability to the casein varies with the composition of the milk.

On the basis of their findings, they conclude that there is no very definite relation between the coagulating temperature of evaporated milk and the

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true acidity, as measured by determining the hydrogen-ion concentration of the milk before sterilization, and a very small increase in the acidity from the normal for that milk will cause a distinct lowering of the coagulating temperature of the evaporated milk.

Fleming and Nair (5) after an extensive study of the value of the titration test for acidity, made the following conclusions: the normal acidity of composite herd milk as received at the factory is 0.140 per cent; that where milk is handled in a clean and careful manner it will not be rejected on the basis of any acid test now in use; the value of the acid test in checking the methods of production is, accordingly, clearly demonstrated and its ease of application combined with this demonstrated reliability warrants its use until such time as some other equally rapid and more dependable method of determining the quality of milk has been perfected; that the percentage of cows and herds showing abnormally high acid is so small as to be negligible and that the manufacturer is doing no injustice to the producer when he insists that all milk must be delivered with an acidity below 0.17 or 0.18 per cent, particularly when such test is applied as an adjunct to the nose and palate of the experienced inspector.

Sommer and Hart (6) suggest the following procedure in cases where the acidity is persistently high and very evidently due to a high apparent acidity.

1. Determine the apparent acidity of the milk at intervals of several weeks.

2. Allow an increase in acidity (*e.g.*, 0.03 per cent) due to slight fermentation that is likely to occur before delivery.

3. If the apparent acidity at the farm was 0.17 per cent, then reject the milk if the acidity exceeds 0.20 per cent.

McInerney (7) concludes after an investigation on the acidity of fresh milk that fresh milk which shows a high percentage of solids not fat and a high percentage of ash shows a high percentage of apparent acidity and that fresh milk comparatively low in solids not fat and in ash shows a lower percentage of apparent acidity.

Rice and Markley (8) studied the natural acidity in freshly drawn milk and accounted for it as follows:

CO_2	in	amount	equivalent	to	.01	to	.02%	lactic	acid	
Citric acid	"	"	"	"	.01	"	"	"	"	
Albumin	"	"	"	"	.01	"	"	"	"	
Casein	"	"	"	"	.05	"	.08%	"	"	
Phosphates	"	"	"	"	the difference					

It is well known that in milk having a high fat content there is also a high percentage of ash and solids-not-fat, such as casein and albumin. On the basis of the conclusions of Fleming and Nair, and of McInerney, and the suggestions of Sommer and Hart, and the findings of Rice and Markley, this investigation was undertaken. To the author it seemed logical to conclude

that since the fat generally varies directly as the solids not fat, though not proportionately, and since milk high in solids not fat is also high in acidity, there should also be some relationship between fat content of milk and titratable acidity.

EXPERIMENTAL

Samples of milk from individual cows in the University herd were taken each milking for a period of about 4 months. The University herd is made up of cows of the Holstein, Jersey, and Guernsey breeds. As soon as a sample was taken, a 9 c.c. portion was pipetted into an evaporating dish and about 5 drops of a 1 per cent alcoholic solution of phenolphthalein indicator added. N/10 normal NaOH was then stirred into the mixture until it became a faint pink and remained so upon continued stirring. Care was taken not to exceed the end point and all samples were tested as uniformly as possible. The remainder of the sample was then tested for butterfat by the regular Babcock procedure. Any abnormalities in the condition of the cow were carefully noted. Approximately 1300 samples were run in all and the experiment was continued from February into July. These months represent nearly a maximum variation in weather conditions in Arizona. A biometrical study was then made of the data on hand, the results of which are presented herein.

RESULTS

The results of this study showed a constant increase in the titratable acidity of milk as the per cent of fat in the milk increased up to five and nine tenths per cent. Above this point the acidity decreased. This was thought to be due to the fact that milk containing above 5.9 per cent fat is unusual and consequently often abnormal; abnormal milk usually tests low in apparent acidity. For an increase of 4 per cent in fat there was an increase of .02328 per cent in apparent acidity. This is equal to .00582 per cent average increase in apparent acidity for every one per cent fat increase.

TABLE 1

Mean titratable acidity for different levels of fat

Fat %	Mean	Standard deviation
2.0–2.4	.10967	.01804
2.5–2.9	.11457	.01458
3.0–3.4	.12129	.01571
3.5–3.9	.12215	.01216
4.0–4.4	.12651	.01641
4.5–4.9	.12825	.01583
5.0–5.4	.13237	.01486
5.5–5.9	.13495	.01545
6.0–6.9	.12700	.01454
7.0 and above	.12269	.01342

Difference 2.0 to 5.9% fat = .02328 per cent apparent acidity.
1267 samples

Actually, in some instances the increase was slightly greater than this and in some cases it was a little less. (See Table 1.)

It was shown that the normal variation in the acidity of milk of different levels of fat from the Holstein and Guernsey breeds was approximately the same as when all milk was considered together. In Jersey milk this was not found to be the case. The variation was very small in Jersey milk. (See Table 2.) This can probably be partially accounted for by the fact

TABLE 2

Per cent acidity at different levels of fat in milks from different breeds

Jerseys			Guernseys			Holsteins		
% Fat	Mean	Standard deviation	% Fat	Mean	Standard deviation	% Fat	Mean	Standard deviation
						Below 3.0	.11287	.01562
			Below 4.0	.12381	.01362	3.0–3.9	.12199	.01396
Below 5.0	.12829	.01437	4.0–4.9	.12955	.01404	4.0–4.9	.12671	.01570
5.0–5.9	.13169	.01614	5.0–5.9	.13516	.01367	5.0 and above	.12615	.01389
6.0–6.9	.13196	.01361	6.0 and above	.12071	.01193			
7.0 and above	.12421	.0370						

that the normal variation in fat content of milks from different cows of the Jersey breed is less than is the case in the Guernsey and Holstein breeds, thus the range of normal milk in the case of the Jersey is less than with the Holstein and Guernsey.

A study of the titratable acidity at different levels of fat from individual cows shows that as a general rule the titratable acidity of the milk from a single cow tends to remain fairly constant and does not vary directly or indirectly with the fat. This is to be expected as it has often been shown that the solids not fat in a cow's milk tends to remain fairly constant under normal, constant, environmental conditions (13).

It was found that as the weather warmed up, the mean titratable acidity of all the milk tested tended to go down while the fat remained fairly constant. (See Table 3.) This can be expected because several experiments

TABLE 3

Monthly variation in per cent acidity and fat

Month	% fat	Mean titratable acidity
March	4.309	.13045
April	4.350	.12567
May	4.293	.12226

have shown that as winter conditions change to summer, the solids not fat content of the milk produced tends to decrease. (9, 10, 11.) As the S.N.F. decreases, the acidity would also decrease (8).

As is shown in Table 4, in the morning the increase in titratable acidity

TABLE 4

Variations in per cent acidity at various levels of fat from morning to night

Morning		Afternoon	
% Fat	Mean titratable acidity	% Fat	Mean titratable acidity
Below 3.0	.11789	Below 3.0	.10931
3.0–3.9	.12385	3.0–3.9	.12087
4.0–4.9	.12607	4.0–4.9	.12786
5.0–5.9	.12818	5.0–5.9	.13426
Above 6.0	.11864	Above 6.0	.12778

for each increase of one per cent of fat was not as great as in the afternoon milking. In the afternoon, the milk varied slightly more than the average increase in acidity for the milk taken as a whole. In the morning, the opposite was the case.

The acidity of the milk from cows that were sick was found to be consistently abnormally low. (See Table 5.) This was not due to udder infec-

TABLE 5

Effect of sickness and injury, etc.

Per cent acidity	Fat
.11	4.6
.10	7.3
.12	6.8
.10	5.4
.09	4.4

tion in these cases, but the cows were sick from digestive disturbances.

Three cows in the herd showed figures which were abnormal throughout the test period. Two of the cows had milk which tested abnormally low in acidity at all times, while the other animals' milk tested abnormally high in acidity at all times. (See Table 6.) These abnormal cows are often found in herds, but do not ordinarily influence materially the mixed herd milk.

Cows near the end of their lactation period were found to produce milk which was abnormally low in acidity. (See Table 7.) This is contrary to the findings of McInerney (7) but confirm the reports of Miyawaki (12).

It was found that the milk from fresh cows is abnormally high in acidity, but that as time progresses the milk goes lower and lower in acidity until after approximately 30 days the milk is normal. (See Table 8.) This is

TABLE 6

Abnormal cows

Ruby		No. 193		No. 199	
Per cent acidity	Fat	Per cent acidity	Fat	Per cent acidity	Fat
.12	4.7	.09	2.7	.15	4.4
.11	6.7	.10	2.8	.15	4.8
.12	4.0	.10	2.6	.15	4.0
.13	6.2	.10	2.6	.15	3.9
.13	4.5	.10	2.8	.14	4.2
.11	6.6	.08	3.2	.15	4.9
.12	4.5	.07	3.4	.15	5.4
.12	6.0	.08	3.3	.15	5.4
.12	6.5	.08	2.8	.16	4.1
.10	3.9	.07	1.9	.15	5.0
.11	6.4	.10	2.7	.15	4.6
.12	4.8	.09	3.0	.14	4.5
.10	6.4	.10	2.7	.15	4.5
.12	5.1	.10	2.9	.14	4.6

also contrary to the observation of McInerney (7) but again confirms the work of Miyawaki (12).

TABLE 7

Percent of acidity in milk of cows near end of lactation

No. 83		No. 95	
Per cent acidity	Fat	Per cent acidity	Fat
.11	4.5 3/15/38	.12	8.5 5/17/38
.11	6.1	.13	6.0
.11	6.3	.12	8.7
.09	5.7	.13	6.9
.09	4.7	.12	6.0
.10	7.2	.12	5.6
.08	5.2 dried up 4/14/38	.11	9.3 dried up about 6/1/38

SUMMARY AND CONCLUSIONS

Data are presented herein which show that milk in general increases in apparent acidity as the fat content increases up to 6 per cent butterfat, from this point on the acidity decreases. This phenomena was also noted in milk taken from Holstein cows exclusively and from Guernsey cows exclusively, but it was not so apparent in Jersey milk. Individual cows likewise did not show this variation. As summer conditions became prevalent, the mean titratable acidity of milk in general decreased. Milk from the morning milking did not display the same trend in variation in acidity that was displayed by milk from the afternoon milking.

A small number of cows tested showed abnormal tests at all times. Two animals producing milk which was always abnormally low in acidity and one cow produced milk that was always abnormally high in acidity.

Cows advancing in their lactation period and sick cows produced milk

TABLE 8

Per cent acidity in milk of fresh cows

Royal Belle		201		Pansy		87		209	
% Acidity 3/16/38 1st Milking	Fat	% Acidity 3/21/38 1st Milking	Fat	% Acidity 3/25/38 1st Milking	Fat	% Acidity Fresh 3/28/38	Fat	% Acidity 3/3/38 1st Milking	Fat
.17	5.6	.23	4.7	.11	6.2	.15	2.9	.14	4.3
.17	5.2	.20	6.5	.12	2.6	.15	4.3	.14	4.1
.16	5.1	.19	4.4	.15	5.8	.15	4.2	.14	4.7
.16	5.5	.17	4.7	.15	5.3	.15	4.7	.14	3.3
.17	4.2	.16	3.8	.15	5.4	.14	6.7	.12	4.1
.15	4.4	.17	3.6	.14	3.4	.14	4.9	.12	4.2
.16	4.0	.16	3.1	.15	3.9	.15	6.0	.12	4.6
.15	4.5	.15	4.5	.14	5.6	.13	5.7	.13	3.7
.16	4.1	.15	3.5	.15	4.1	.14	5.4	.13	3.3
.15	4.5	.15	4.0	.15	5.1	.13	5.7	.13	4.6
.16	4.7	.13	3.3	.14	5.9	.12	5.3	.13	3.4
.15	5.3	.13	4.5			.14	5.5	.13	3.9
.15	5.0	.13	4.4			.12	5.7	.13	3.5
.14	5.0	.12	4.1			.13	6.3	.13	4.2
.14	5.0	.14	3.2			.12	5.4	.13	2.9
.15	4.5	.13	3.5			.12	6.0	.13	3.4
.15	4.9	.12	4.8			.12	6.0	.13	3.3
.14	5.0	.12	3.5			.12	5.3		
		.12	4.2						
4/27/38		4/4/38				4/20/38			

abnormally low in acidity. Cows after freshening, for a period of about 30 days, produced milk abnormally high in acidity.

On the basis of this study the author is inclined to agree with the conclusions of Fleming and Nair (5) namely that the ease of application of the acidity test and its reliability warrant its continued use until some better test is found and that it does not normally work an injustice on the producers of even the richest milk. The author urges, however, that users of the titratable acidity test adopt a limit of acidity at which milk will be acceptable that varies directly as the fat, increasing the limit .01 per cent for every 2 per cent increase in fat content up to 6 per cent. For example, a standard for 2 per cent milk could be set at .17 per cent acidity, for 3 per cent milk at .175 per cent acidity, .18 per cent for 4 per cent milk, and .19 per cent for 6 per cent milk, or any other standard which they might choose as being suitable for their conditions.

The recommendations of Sommer and Hart (6) are also heartily approved of as being worth-while steps to take in the case of consistently high acid milk.

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OXIDIZED FLAVOR IN MILK. VII. STUDIES OF THE EFFECT OF CAROTENE AND ASCORBIC ACID IN THE FEED OF THE COW ON THE SUSCEPTIBILITY OF THE MILK TO METAL-INDUCED OXIDIZED FLAVOR

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Feed was one of the earliest factors known to influence the susceptibility of milk to oxidized flavor. Kende (10) in 1932 reported that oleaginous (oxidized) flavor in milk seemed to occur only during the winter, and that green feed as well as fresh hay produced from it contained considerable amounts of reducing substances which tended to prevent oxidized flavor from developing. Guthrie and Brueckner (9) concluded that dry feed was not the sole cause of the development of this defect inasmuch as there was a variation in the intensities of the oxidized flavors from different quarters of the same udder. Anderson (1) and co-workers (2) have shown that feeding carrots or artificially dried alfalfa aided in eliminating this defect. Their observations led them to believe that off-flavored milk from individual cows might be caused by dietary deficiencies.

Whitnah, Martin, and Beck (14) have found that all samples which develop oxidized flavor are below the breed average in intensity of fat color. However, not all samples low in color develop an off-flavor. In the feeding of dehydrated young oat plants (containing 103 mg. of carotene per lb. of plants) and carotene concentrate (containing 150 mg. of carotene per lb. of concentrate) it was found that 1 pound of the concentrate was equivalent to about 4 pounds of the dehydrated oat plants in improving the flavor. This difference could not be accounted for on the basis of carotene content alone. They eliminated this flavor defect in two to four days by feeding the concentrate. The color of the fat was not increased for some time after the flavor improved. Whitnah *et al.* (15) found that supplementing the ration with carotene produced an increase in the carotene content of the blood and eliminated the oxidized flavor in the milk of individual cows. Stebnitz and Sommer (12) found no relation between the carotene content, as evidenced by the color of the fat and the stability of the fat toward oxidation.

Garrett *et al.* (7) (8) found a correlation of 0.6 between vitamin C content and the flavor of the milk from individual cows. When the vitamin C content of the milk was high the flavor of the milk was usually good. Also

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a correlation was found between the color of the milk and the flavor. They concluded that a definite relationship exists between the vitamin C content and the yellow color in the milk from individual cows of both the Guernsey and Holstein breeds as indicated by correlation coefficients of over 0.5 and over 0.6, respectively.

Dahle and Palmer (6) were unable to eliminate oxidized flavor by the direct addition of 8 mg. of pure beta-carotene per liter of milk.

Chilson (5) substantiated the work of Kende (10) that the direct addition of small quantities of ascorbic acid to milk would prevent the development of oxidized flavor.

More recently Brown (4) and co-workers have demonstrated that the feeding of lemon juice and tomato juice to cows on dry feed greatly reduced the susceptibility of the milks to oxidized flavor development. They explained this effect on the basis of the vitamin C contained therein, since they found that the daily feeding of 0.5 gram of ascorbic acid reduced the susceptibility.

Because it is now possible to supplement the basic ration of the cow with either ascorbic acid or carotene from commercial sources, it seemed desirable to know whether carotene or ascorbic acid, or both, were necessary in order to eliminate the susceptibility of the milk to oxidized flavor. Although carotene has been shown to eliminate naturally occurring oxidized flavor in the milk of individual cows, no studies have been reported on the effect of a carotene supplement on metal-induced oxidized flavor. Likewise, further study is needed concerning the manner in which ascorbic acid affects the susceptibility of the milk to the development of oxidized flavor. To obtain further information on these points the following experiment was planned and conducted.

EXPERIMENTAL

For use in this experiment, six cows, whose milks were susceptible to oxidized flavor when contaminated with copper, were selected and placed on a ration low in carotene. The ration consisted of a grain mixture of 150 lbs. ground oats, 100 lbs. cottonseed meal, 100 lbs. wheat bran, 5.3 lbs. salt, and 7 lbs. of steamed bone meal, with timothy hay as the roughage.

Samples of milk were collected from each cow each evening and pasteurized in bottles. Following pasteurization the samples were divided into two lots and one lot was contaminated with copper at the rate of 1.3 p.p.m., added from a copper sulphate solution, while the other served as a control. Both samples were then stored in ice water for three days, after which they were scored for flavor by at least three judges familiar with oxidized flavor. On three consecutive days each week, large samples of the milk from each cow were taken and vitamin C and carotene determined. The vitamin was determined on individual samples by titration as suggested by Sharpe (13). The samples of milk were prepared for carotene analysis by gravity separa-

tion of the cream followed by churning in a small glass churn. The butter thus obtained was melted and centrifugalized in Hart's casein tubes in an electrically heated centrifuge for 15 minutes, after which the clear liquid butter oil was decanted into a clean dry jar. A composite sample was made from this butter oil of three consecutive days and the carotene analysis made according to the method of Baumann and Steenbock (3) as modified by Rogers and associates (11).

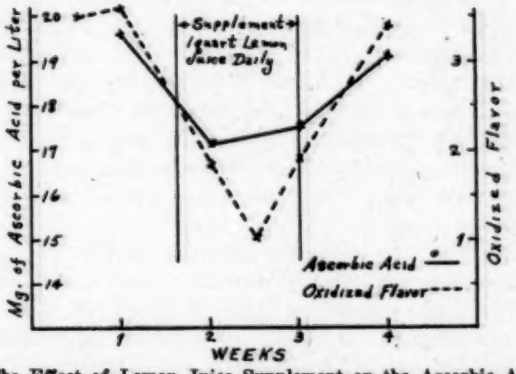

FIG. 1. The Effect of Lemon Juice Supplement on the Ascorbic Acid Content of the Milk and the Susceptibility of the Milk to Oxidized Flavor. Oxidized flavor values: 1, very slight oxidized flavor; 2, slight oxidized flavor; 3, moderate oxidized flavor; 4, pronounced oxidized flavor.

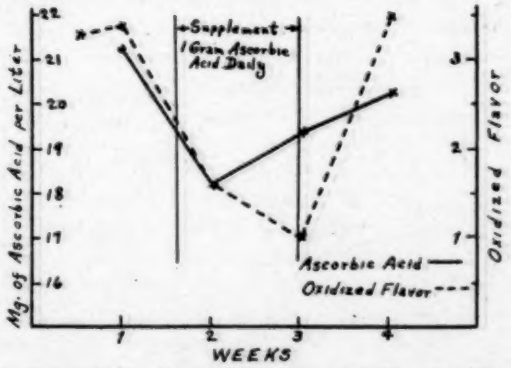

FIG. 2. The Effect of Ascorbic Acid Supplement on the Ascorbic Acid Content of the Milk and the Susceptibility of the Milk to Oxidized Flavor.

After a five-day preliminary trial on the new ration the cows were divided into two groups of three cows each. Group one was given a daily supplement of one quart of freshly extracted lemon juice while the other

was given a daily supplement of one gram of crystalline ascorbic acid. Both groups were held on the basic ration with the vitamin C supplement for ten days, during which time the effect of the supplement to the low carotene ration was being studied in relation to metal-induced oxidized flavor. The results of this study are shown in figures 1 and 2. Because all control samples (not contaminated with copper) were free from oxidized flavor they were omitted from the graph.

Figure 1 shows the results obtained with lemon juice while figure 2 shows the results of the ascorbic acid supplement. Although the oxidized flavor was not entirely eliminated, it was greatly decreased as a result of the vitamin C supplement. With four of the six cows used in this experiment the flavor was decreased to the point where for three consecutive days no oxidized flavor was detectable. In the milk from the other two cows the flavor was greatly decreased but not entirely eliminated. Presumably the flavor could have been eliminated entirely had the supplement been increased or continued for a longer period.

The next ten days following the discontinuance of the vitamin C supplement, the cows were continued on the basic ration and the intensity of the oxidized flavor again reached an intensity similar to that observed at the start of the experiment. At this time a carotene supplement was added (Pur-A-Tene—carotene in oil) to the ration at the rate of ½ pound (containing 350 mg. of carotene) per cow per day for a period of 20 days. During this period the effect likewise was studied of the carotene content of the ration on the intensity of the metal-developed oxidized flavor of the milk.

The results for four of the cows used in this trial are shown in figure 3,

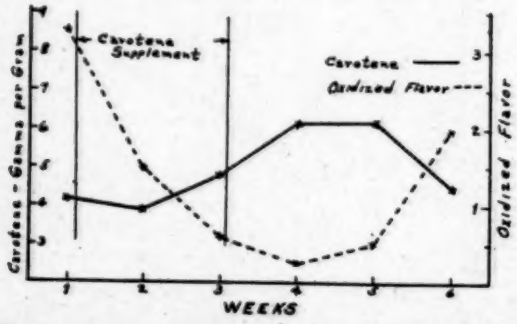

FIG. 3. The Effect of the Carotene Supplement on the Carotene Content of the Milk and the Susceptibility of the Milk to Oxidized Flavor.

while the data for the two remaining cows are shown in figure 4. The oxidized flavor in the milk from the cows whose data are shown in figure 4 did not decrease as rapidly as it did in the other animals and for this reason

the carotene supplement was doubled for an additional week. This was sufficient to reduce greatly the intensity of the oxidized flavor developed. The results of these trials show that a carotene supplement in the feed will render the milk non-susceptible to metal-induced oxidized flavor. As in the previous experiment, all the control samples were free from oxidized flavor and hence were omitted from the figures. Supplementing the ration with carotene resulted in an increase in carotene in the milk.

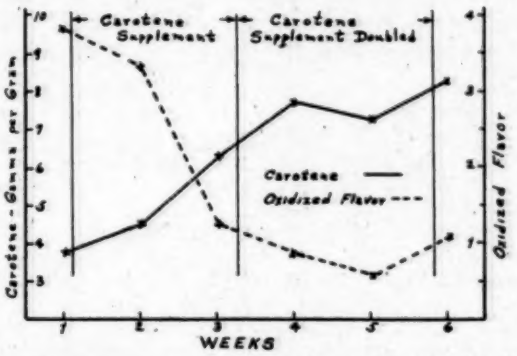

FIG. 4. The Effect of the Carotene Supplement on the Carotene Content of the Milk and the Susceptibility of the Milk to Oxidized Flavor.

DISCUSSION

The results of this experiment show that the addition of either ascorbic acid or carotene to the ration will render the milk less susceptible to metal-induced oxidized flavor. By supplementing the ration with carotene, the carotene content of the milk is increased, while the addition of ascorbic acid to the ration does not seem to increase materially the ascorbic acid content of the milk. Apparently the ascorbic acid supplement acts in some manner other than by directly increasing the ascorbic acid content of the milk. The addition of one gram of ascorbic acid or one quart of freshly extracted lemon juice to the ration of each cow resulted in a slight increase in the carotene content of the milk produced. Likewise, when carotene was added to the ration there resulted an increase in the ascorbic acid content of the milk. Despite considerable daily variation in the ascorbic acid content of the milks, when the three consecutive days were averaged, this trend is still evident. No explanation is offered at this time for this effect. A typical example of this relationship can be seen in the complete data for one cow, shown in figure 5, but all of the cows showed a similar tendency.

It was thought at the beginning of the experiment that when the animals were placed on a low carotene ration some of their milks might develop an oxidized flavor spontaneously. However, this did not occur, indicating that

some factor other than a low carotene content is responsible for the incidence of naturally occurring oxidized flavor.

These results are in agreement with the findings of Anderson and his co-workers in that carotene in the ration tends to render the milk non-susceptible to oxidized flavor development. The discrepancy with the work of Stebnitz and Sommer may be explained on the basis that they were working on the ordinary chemical oxidation of butter fat when they found no relation between the carotene content, as evidenced by the color, and the stability of the fat toward oxidation, whereas the oxidation involved in the process of developing oxidized flavored milk is somewhat more involved.

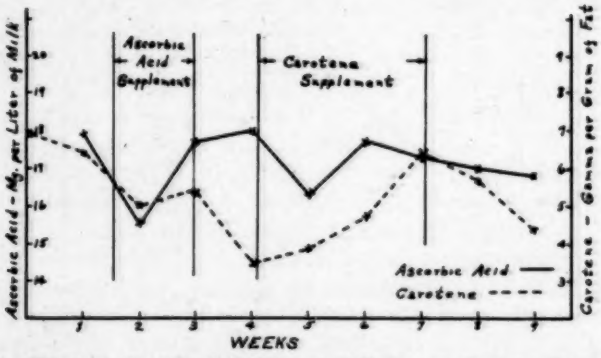

FIG. 5. Effect of Ascorbic Acid Content of Ration on Carotene Content of Milk and Effect of Carotene Content of Ration on Ascorbic Acid Content of Milk.

In the work of Dahle and Palmer the carotene was added directly to the milk and, in order to affect the susceptibility of the milk, it must apparently be in solution in the fat.

SUMMARY AND CONCLUSIONS

1. Ascorbic acid fed at the rate of one gram per day reduced considerably the tendency for metal-induced oxidized flavor to develop, although it did not materially increase the ascorbic acid content of the milk.

2. Carotene fed at the rate of 350 mg. per day greatly reduced the tendency for metal-induced oxidized flavor to develop and resulted in an increased amount of carotene in the milk.

3. The mechanism whereby oxidized flavor is developed spontaneously is influenced by some factor or factors other than that the ration is low in carotene.

4. Ascorbic acid fed to cows on a ration low in carotene seemed to increase slightly the carotene content of the milk produced, and, conversely, feeding carotene to the same animals on the low-carotene ration apparently increased somewhat the ascorbic acid content of the milk.

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WATER SORPTION BY DRY MILK SOLIDS. I. THE EFFECT OF PROCESSING TREATMENTS ON VOLUME CONTRACTION

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Dry milk solids occupy an important place in the dairy industry, being used for human food, animal feed and for some industrial purposes, with human consumption taking the largest amount. Among the human food uses most are affected by the dry milk solids—water relationships. For reconstituting to the fluid state complete solubility (actually colloidal dispersion) is desirable. For use in bread making, which is one of the more important human uses, complete solubility is not required but the maximum ability to hold water in a fixed state is desirable. The effects of processing treatments upon solubility have been established and are well known. The factors affecting water sorption have not been established. It is the purpose of this study to investigate certain phases of this problem.

Water sorption is the taking up of water by colloidal materials and holding it with some degree of force. It includes absorption, an intramicellar phenomenon, and adsorption, a surface or intermicellar relationship. It is considered synonymous with hydration, but may be different from the manifestation of "bound water" as commonly measured. Water sorption exhibits itself through a positive heat of reaction as contrasted to solution which is endothermic; through a lowering of the aqueous vapor pressure; through a swelling of the colloidal material showing a definite swelling pressure; and through a volume contraction of the entire system.

REVIEW OF LITERATURE

So voluminous is the material that it is beyond the limits of this paper to attempt a complete bibliography covering the subject of hydration and its measurement. Consequently only that literature will be cited which has direct bearing on the subject at hand.

There have been many methods devised for the estimation of the water sorption capacity of colloidal materials. Newton and Gortner (1) have devised a technique for measuring "bound" water that depends upon the depression of the freezing point. Briefly, the freezing point of a solution of the material is measured and then a predetermined quantity of sucrose is dissolved in the liquid and the freezing point depression noted. The difference between the theoretical depression and the actual depression is caused by some of the water being "bound," or not free to dissolve sucrose. The quantity can be calculated from the above values. Gortner and Sharp (2) have used viscosity as a measure of hydration of wheat flours; the flour with the greater hydration capacity will yield the more viscous solution.

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Hansen (3) has used the heat of hydration given off when dry milk is put into water as a value from which to calculate the moisture content of the dry milk. Obviously, such a method in order to be valuable for moisture determination must be applied to dry milks of the same capacity to become hydrated. Kuhlman and Golossowa (4) have used a modification of Newton and Gortner's "bound" water method in studying breadmaking. They have substituted the determination of the refractive index for the freezing point. Thiessen (5) has described a number of methods for measuring the swelling of colloidal materials. These include measuring the increase in weight, the aqueous vapor pressure of the material at definite water contents, and the increase in dimensions of the swelling material.

The thermodynamic relations of water sorption have been studied by various investigators. Fricke and Lüke (6) have shown that there is a direct relation between volume contraction and heat of imbibition and that casein shows an integral volume contraction of approximately 40 cubic millimeters per gram of dry material. Katz (7) has discussed the laws of swelling from the thermodynamic viewpoint. Stamm (8) has investigated the relationships between water and cellulosic materials, particularly wood, and applied thermodynamic interpretation to his results.

The dilatometer has been used for many years as an instrument with which to measure small changes in volume. Svedberg (9) used a dilatometer for studying the hydration of gelation. He found a volume contraction of 54 cubic millimeters per gram of gelatin. Hampton (10) in a brief note has described a dilatometer designed particularly for measuring the hydration of colloids. Soil scientists have frequently employed the dilatometer to determine the water holding capacity of soils. An example is given by Bouyoucos (11). Cole (12) has used a dilatometer in the field of dairy products to study freezing in ice creams. Recently, Rishoi and Sharp (13) have measured the volume change accompanying fat solidification in cream in a dilatometer.

The freezing point "bound" water technique of Newton and Gortner described above has been used in connection with dairy products. Pyenson and Dahle (14, 15, 16) have made an extensive investigation of dairy products using this method. They report that the solids of skim milk "bind" 29.1 grams of water per 100 grams of solid when rennet coagulated and 25.5 grams per 100 grams of solid when acid coagulated. Concentrated milk is reported to bind 36–39 grams of water per 100 grams of milk solids. Fresh dry milk solids (vacuum drum process) showed a water binding capacity of 46.5 grams per 100 grams solids immediately upon wetting and 61.1 grams after aging 24 hours in the solution. The water binding capacity of the dry milk solids had decreased four weeks after manufacture and still further after eight weeks. Gelatin showed no water binding capacity by this method.

Skovholt and Bailey (17, 18) have compared baking qualities of dry milk solids prepared by different methods, also they have attempted to correlate the viscosity of the water suspensions of dry milk solids with water absorption in bread dough. Roller process solids gave higher viscosities but not higher absorption in the doughs. They state that water absorption in the dough is not directly measured by viscosity of the suspension and that these properties do not parallel baking strength. Likewise, Johnson and Ward (19) have reported that the viscosity of condensed skim milk is not related to baking quality. Greenbank and associates (20) also have studied the effect of heat on the baking quality of milk. They consider the viscosity of the reconstituted product to be a measure of the water holding capacity of the dry milk.

Supplee (21) made a study of the moisture content of milk powders in equilibrium with atmospheres of varying humidities. He found that milk powders prepared in different ways varied somewhat in their ability to take up moisture from the air. His method was to suspend the powder in an atmosphere of constant known humidity and determine the moisture content at equilibrium. Samples represented powders manufactured by the roller and by the spray processes, with and without precondensing. Values are given for humidities as high as 80 per cent and range from 13.0 per cent moisture at 80 per cent humidity for a spray powder from precondensed milk to 14.97 per cent moisture at 80 per cent humidity for roller powder from precondensed milk. One trial in which the sample was allowed to absorb 10 per cent moisture and then redried had a lower absorbing capacity when later exposed to a moist atmosphere.

EXPERIMENTAL PROCEDURE

The search of the literature reveals a large number of experimental methods available for investigating water sorption. Many are subject to severe criticism, and others are ill adapted to the investigation of dry milk solids. Those which have been used for dairy products seemed to fail to yield the type of information desired in this study. Because volume contraction as measured in a dilatometer is a method by which the progress of the reaction can be followed, and which lends itself readily to studying the effects of different fluids and agents, and which has been shown to be directly related to water sorption, it was selected as a method with which to study certain phases of this problem.

A description of the apparatus and method is detailed in an earlier paper (22). Briefly, the apparatus consists of a bulb flask attached to capillary tube and having side-arms for filling. The capillary tube has been calibrated with mercury. A quantity of dry milk solids is weighed into the flask, a few drops of toluene added as preservative, and the flask attached to the capillary by means of a ground glass joint. If it is desired to limit the amount of water, the proper amount is introduced through a side arm and

the whole layered over with an immiscible oil extending into the capillary. If an unlimited amount of water to obtain maximum sorption is desired, as was the case in the experiments reported here, the flask is filled with water and the water is extended into the capillary. The apparatus is maintained isothermally in a water bath, under the conditions here reported at 20 degrees C. The height of the liquid is read at the beginning and at intervals thereafter until no further change occurs.

From the change in height of the liquid, the previously calibrated dimensions of the capillary, and the weight of dry material, the volume contraction per unit of solids can readily be calculated.

EXPERIMENTAL DATA

Samples of dry milk solids prepared by the spray process[1] and on the atmospheric roller dryer have been examined by this technique. These samples were allowed to remain in contact with water in the dilatometer until volume contraction had stopped. This yields maximum volume contraction. The values obtained in terms of cubic millimeters per gram of dry material for the differently processed samples are shown in the following table (Table 1).

TABLE 1

The maximum volume contraction of dry milk solids processed by different treatments

Sample no.	Moisture %	Acidity % reconstituted	pH reconstituted	Preheating temperature* C	F	Mfg. process	Volume contraction
1	3.8	0.165	6.80	60	140	Atm. Roll.	27 cu. mm./gm.
2	3.5	0.165	6.80	71.1	160	" "	31 " " "
3	3.2	0.165	6.80	76.7	170	" "	36 " " "
4	3.8	0.165	6.85	82.2	180	" "	30 " " "
5	3.1	0.165	6.80	93.3	200	" "	32 " " "
**6	3.7	0.160	6.80			" "	27 " " "
7	2.4	0.160	6.80	71.1	160	Spray	67 " " "
8	2.1	0.160	6.75	76.7	170	"	82 " " "
9	2.8	0.160	6.75	82.2	180	"	53 " " "
10	2.4	0.160	6.80	93.3	200	"	51 " " "

* Skim milk held at these temperatures for 30 minutes.
** Sample 6 is a commercial product prepared for the baking trade.

These results are shown graphically in the following chart (Figure 1).

The time relationships are of interest not only because they show the length of time necessary for maximum contraction to occur but also because they show the effect of processing treatments upon the rate of contraction. Figure 2 shows the data obtained with the samples prepared by the atmospheric roller process.

[1] The samples of spray powder were prepared at the plant of the Milk Producers Association of Central California, Modesto, California, through the courtesy of the management.

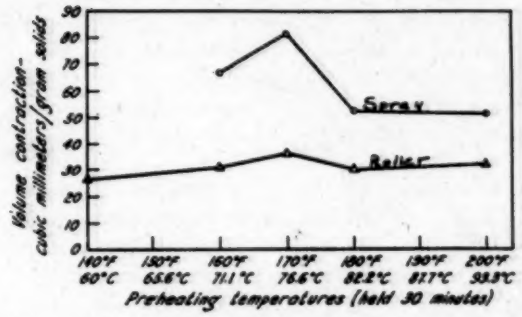

FIG. 1. The effect of preheating temperatures on volume contraction.

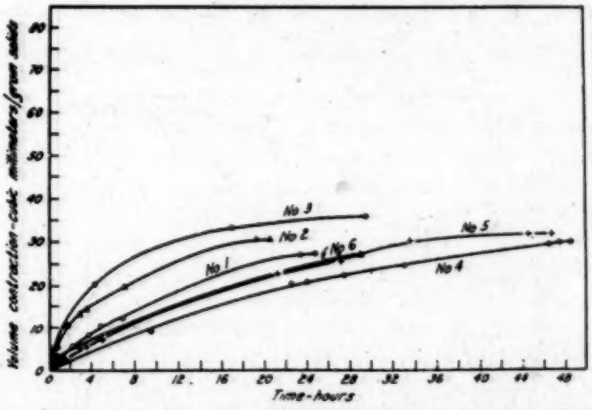

FIG. 2. The rate of volume contraction of atmospheric roller dry milk solids.

The information concerning the samples prepared by the spray process is shown in Figure 3.

It has been shown that the lactose present in dry milk solids prepared by the spray and roller processes is in the glass form unless the dried products are allowed to cake (23) in which case the lactose crystallizes in the alpha hydrate crystalline form (24), and in solution, lactose is present as an equilibrium mixture of the alpha and beta configurations (25). Since lactose undergoes these changes when exposed to water it seemed desirable to determine the effect of the change from the glass form to the crystalline form upon the volume contraction. Consequently, some dry milk solids from sample no. 8 were allowed to cake in a moist atmosphere and then redried to their original moisture content. There was no significant difference in the extent of volume contraction before and after caking, but there was a difference in the rate as shown in Figure 4.

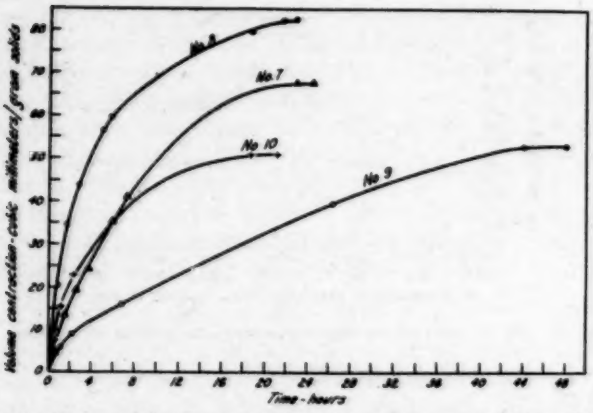

FIG. 3. The rate of volume contraction of spray process dry milk solids.

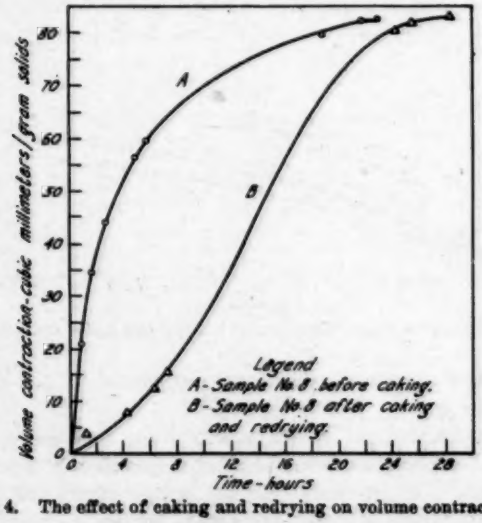

FIG. 4. The effect of caking and redrying on volume contraction.

DISCUSSION OF RESULTS

The data presented show only relative values for the degree of water sorption; work is in progress which will show the extent of volume contraction at different water levels. They do show, however, that different processing treatments produce noticeable effects in the properties of the dried materials.

Examination of Figure 1 shows that dry milk solids prepared by both processes show the same general reaction to the preheating treatment. There

is a maximum contraction at 76.7 degrees C. (170 deg. F.) with each method, the effects being more marked with the spray process solids. It seems likely that the lower level of the roller process solids and the decreased values for the higher heat treatments are direct results of excess heat causing denaturation of the protein. There appears to be an optimum at about 76.7 degrees C. (170 deg. F.).

Figures 2 and 3 reveal some interesting comparisons. Again, the sequence of events occurs in the same order in the two types of dry milk solids and are more pronounced in the material by the spray process. The volume contraction is complete in about 20 to 22 hours for all of the spray samples except the one processed at 82.2 degrees C. (180 deg. F.) and in about 24 to 28 hours for the roller samples except the ones processed at 82.2 degrees C. (180 deg. F.) and 93.3 degrees C. (200 deg. F.). In both cases the 82.2 degrees C. (180 deg. F.) samples required about 48 hours for maximum volume contraction to occur. The roller sample preheated at 93.3 degrees C. (200 deg. F.) reacted somewhat faster than that processed at 82.2 degrees C. (180 deg. F.) but not as rapidly relatively as the 93.3 degrees C. (200 deg. F.) spray sample. Several trials were made in order to verify these results and no adequate explanation is available at this time. Heat denaturation would explain three of the four but the rapid rate of the 93.3 degrees C. (200 deg. F.) spray sample seemingly obviates this explanation.

The results shown in Figure 4 may be somewhat at variance from the data presented by Supplee (21) with which he showed that a sample which had been allowed to cake and was redried did not take up as much moisture from the air as it had previous to caking. However, it is known that colloidal materials will not take up the same amount of water from a moist atmosphere as they will from liquid water. The difference in the initial rate of contraction may result from the difference in the state of the lactose. If, in the original sample the lactose is in the form of a glass—a very highly supersaturated solution—this form would have a relatively high attraction for water and would wet easily; whereas, if in the redried sample the lactose is in the form of alpha hydrate, this form might not wet as easily, and since dry milk solids are approximately 50 per cent lactose the wetting of the whole and consequently the volume contraction might be delayed.

It is still debatable as to just what occurs in the volume contraction accompanying water sorption. The shrinkage may result from the compression of the solid resulting from a very strong attraction between the liquid and the solid, or it may result from a change in the association of the sorbed water with a change in specific volume. The latter explanation is generally regarded as the most probable one and, if true, it means a decrease in the specific volume of water of 30–40 per cent (6). On this basis the amount of water sorption can be calculated, and represents one per cent per gram of dry material for each three or four cubic millimeters contraction, depending upon which value is used for the specific volume of the water.

It remains to consider which constituents of milk are responsible for the volume contraction. It is well known that solution as such results usually in negligible volume changes. Preliminary experiments with alpha hydrate lactose by the method used for dry milk solids substantiated this for the lactose portion of the soluble milk constituents. It may be assumed that the mineral constituents act in the same manner. The fat content of the samples was approximately one per cent. In the light of Rishoi and Sharp's recent work (13) the volume change for this amount of fat at the temperature used is negligible. By elimination, the proteins, and possibly minor constituents such as phospholipids, are the only possibilities to contribute to the volume contraction. One may reasonably say then that the volume contraction of dry milk solids results mainly from water sorption by the milk proteins.

SUMMARY AND CONCLUSIONS

1. The volume contraction of dry milk solids prepared by different processing treatments immersed in an unlimited amount of water has been measured at 20 degrees C. in a dilatometer.

2. Dry milk solids preheated at 76.7 degrees C. (170 deg. F.) for 30 minutes before drying showed greater volume contraction in water than solids preheated at other temperatures studied, namely 60 degrees C. (140 deg. F.) (roller only), 71.1 degrees C. (160 deg. F.), 82.2 degrees C. (180 deg. F.), and 93.3 degrees C. (200 deg. F.).

3. Dry milk solids manufactured by the spray process showed greater volume contraction than when manufactured by the atmospheric roller process.

4. The time required for volume contraction to be complete ranged from 20–22 hours for all spray samples except the one processed at 82.2 degrees C. (180 deg. F.) and 24–28 hours for all roller samples except 82.2 degrees C. (180 deg. F.) and 93.3 degrees C. (200 deg. F.) to 48 hours for the samples processed by the higher heat treatments mentioned.

5. The significance of the data is discussed in the light of known facts concerning volume changes accompanying various phenomena and the conclusion is drawn that the volume contraction probably results mainly from the sorption of water by the milk proteins.

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THE SEPARATION OF FAT IN EVAPORATED MILK

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According to Stokes' Law governing the rate of rise of globules or the fall of particles in a medium, the rise of the fat is largely a function of the diameter of the fat globules and the viscosity of the dispersion medium.

Prior to the advent of the homogenizer evaporated milk was sterilized until a very heavy body was produced. This condition had a deterrent effect upon the velocity of rise of the fat but did not prevent it. In more recent years, decrease of the fat globule size through homogenization has permitted the production of a product of greater fluidity and with a decreased tendency to fat rising.

Low storage temperatures, which increase the viscous properties of the product, act as a deterrent to the rising of the fat. Shortening of the storage period and turning the cans at regular intervals are also practices often employed to prevent undue fat separation in evaporated milk.

While the effects of homogenization and viscosity on the rising of fat of evaporated milks have been known, apparently no actual measurements of the rate and the extent of separation have been published. Some observations upon this point will be presented in this article.

EXPERIMENTAL

The evaporated milk was made in 100-pound batches according to the usual commercial procedure. The milk was forewarmed at 95° C. for 10 minutes and concentrated in a small tinned-copper pan at 27 inches vacuum. The evaporated milk was homogenized either once or twice in a single stage machine, canned, and sterilized in a small pilot sterilizer.

Cans which held 160 grams of milk and which were $2\frac{1}{2}$ inches by $2\frac{1}{2}$ inches, outside dimensions, were used. The average height of the column of liquid in the can was $2\frac{3}{16}$ inches.

Viscosity measurements were made on the samples 24 hours after sterilization by means of a 25 cc. capillary viscosimeter. The time of flow into the pipette was taken for a series of pressures measured by means of a water manometer. A uniform pressure was obtained through the use of a 5-gallon reservoir.

The viscosity of the samples was calculated according to the proportion:

$$\frac{Vm}{Vs} = \frac{Dm \times tm}{Ds \times ts}$$ wherein,

Vm = viscosity of the milk

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TABLE 1

The effect of manufacturing processes and storage time upon the separation of fat in evaporated milk

Milk sample	Milk composition		Homogenization pressure	Sterilization treatment		Viscosity of sterilized milk	Butterfat in top third of can after storage at 28° C.				
	Total solids	Fat		Temperature	Time		21 days	46 days	87 days	141 days	252 days
	per cent	*per cent*	*pounds*	*°C.*	*min.*	*poises*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
1	26.10	8.3	1000	116	17	57.5	15.1	17.1	19.3	20.5	22.4
			2500			71.1	9.6	11.7	15.5	17.1	19.3
			2500–1000			71.2	8.8	11.8	14.3	16.0	18.8
2	27.70	7.9	1000	115	15	67.1	16.6	19.0	20.3	20.6	20.8
			2500			87.3	11.7	14.2	16.1	16.8	17.9
3	26.71	8.3	2500	115	15	48.4	12.1	14.6	16.6	18.2	19.5
			2500–1000			57.4	11.7	14.3	16.3	17.9	19.4
			4000			72.5	9.7	11.6	14.1	16.0	17.1
			4000–1000			77.0	9.6	11.2	13.1	15.9	17.2
			2500	115	18½	125.1	10.4	12.4	14.6	17.8	18.5

Vs = viscosity of a 60% sugar solution
Dm = density of milk
Ds = density of sugar solution
tm = time of flow of milk into pipette at the pressure of a 25-inch water column
ts = flow time for sugar solution at same pressure

With the exception of the last milk in the accompanying table (viscosity 125.1 poises), no sample showed a yield value. Correction was not made for yield value in calculating the viscosity of this sample.

The cans of sterilized milk were held undisturbed in storage in a room the temperature of which varied between 25° C. and 31° C. and which averaged 28° C.

Upon conclusion of the storage period, cans to be examined were removed very carefully, without tipping or shaking, to a cold room maintained at −17.7° C. The next day the cans of frozen milk were opened, the solid milk cake removed and sliced into an upper, middle, and lower layer. Each layer was weighed and analyzed for fat.

Fat was determined by the Babcock method, modified by the addition of 1 cc. of normal butyl alcohol to each 9-gram charge of milk. It was found by comparison with the Röse-Gottlieb method that results obtained using this modified Babcock test showed a possible error of ± 0.1% fat.

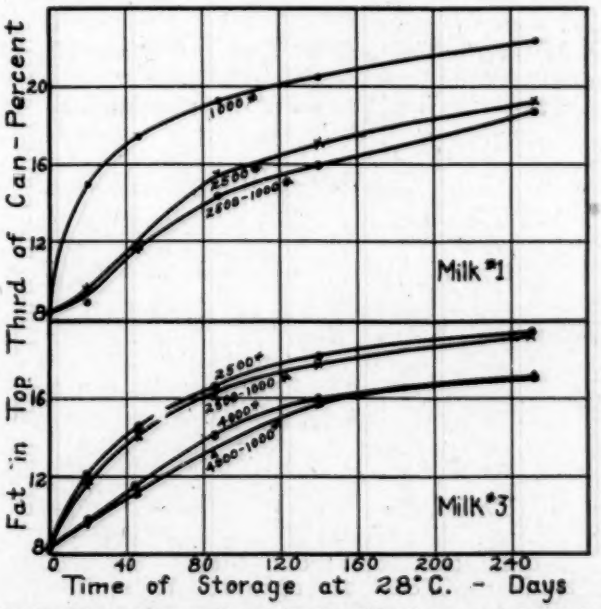

FIG. 1. The effect of storage time on the rise of fat in evaporated milks homogenized at different pressures.

Since the top layer was never exactly one-third, correction for this was made through the use of the weights and tests of the other layers. The corrected figures show the amount of fat which was present in the upper third part of the milk.

Fat separation data were secured on a number of different evaporated milks. Figures from 3 representative samples are given in the accompanying table. The differences between the fat content of the fresh evaporated milk and that of the top layer represents the fat which rose to the top from the lower two-thirds of the can. Data for milks 1 and 3 are plotted in Figure 1.

Although no means were found whereby fat separation could be prevented, this work indicates that effective methods of retarding separation are available for use in the manufacturing process. Two-stage homogenization with a high initial pressure and control of the sterilization process to produce a heavy-bodied milk were helpful in lessening the separation of fat in evaporated milk.

The influence of high viscosity or high homogenization pressures upon the distribution of fat is most noticeable during the first few weeks of storage. As the period of undisturbed storage continues, a noticeable decrease in the rate of fat separation occurs.

SUMMARY

A study of the distribution of fat in cans of evaporated milk during storage showed that high pressures of homogenization, two-stage homogenization, and high viscosity were effective in retarding separation.

SOME FACTORS INFLUENCING THE AMOUNT OF MOLD MYCELIA IN BUTTER[1]

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Mold mycelia in some food products are used as an index of the state of decomposition that existed in the original products before processing. In 1937, Wildman (1) introduced a test which determines, by the examination of butter, the approximate amount of mold contained in the cream from which the butter was manufactured. The technique of this test is similar to the method devised by Howard (2) for determining mold in tomato products. In the examination of butter the results are expressed as the per cent of fields examined which show mycelia fragments. A field is tabulated as positive when the total length of any two mycelia are equal to one-sixth the diameter of the microscopic field. It would appear, at first hand, that by enumerating the mold mycelia fragments in a sample of butter, much information could be obtained as to the age of the cream, temperature of storage, and care in production until manufactured into butter.

In order to obtain information on the significance of mold mycelia fragments in butter, a series of experiments were undertaken to determine: 1. Factors influencing the development of mold mycelia in cream as it may be handled on the producing farm. In this series of experiments raw cream was churned into butter using a laboratory churn. 2. The influence of some manufacturing methods on the mold mycelia content of butter. In this series of experiments pasteurized cream was used and the churnings made in a commercial churn unless otherwise specified.

I. FACTORS INFLUENCING THE DEVELOPMENT OF MOLD MYCELIA IN CREAM

Temperature and time of holding.

To secure information as to the effect of time and temperature of holding cream on the development of mold mycelia, fresh cream was secured from a clean separator, placed in cream cans and held for periods of from three to nine days at average temperatures of 60, 70, 75, and 80° F. To resemble farm conditions, at twelve-hour intervals equal additions of cooled cream were added to the accumulated supply. Twenty-eight trials were conducted to secure possible variations that may have existed in the micro flora of cream. The results obtained are presented in Table 1.

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[1] The data in this paper was taken in part from a thesis presented by Joseph Adams in partial fulfillment of the requirement for the Master of Science degree, and is published with the approval of the Director of the Agricultural Experiment Station.

* Industrial Fellowship of the Dairy and Ice Cream Machinery and Supplies Association.

TABLE 1

The influence of temperature and time of holding raw cream upon the mold mycelia content of the butter

Temperature of holding, °F.		Days held						
		3	4	5	6	7	8	9
		Percentage of positive fields						
60	Max.	4	15	22	—	—	—	27
	Av.	2	7	13	—	—	—	14
	Min.	0	0	6	—	—	—	10
70	Max.	—	6	16	44	74	88	96
	Av.	—	5	7	28	60	73	88
	Min.	—	4	5	17	46	58	80
75	Max.	—	24	25	—	84	100	100
	Av.	—	18	17	—	61	100	100
	Min.	—	10	8	—	53	100	100
80	Max.	10	100	100	100	100	100	100
	Av.	7	79	92	97	94	100	100
	Min.	3	56	72	86	81	100	100

The data show that temperature and time are important factors influencing the rate of growth of mold in cream. An average cream held at 70° F., or lower, for six days produced a butter that was positive for mold mycelia in less than 40 per cent of the fields examined, while cream held for four days at 80° F. produced a butter having 80 per cent of the fields positive. Considering maximum counts, butter with less than 40 per cent of the fields positive could be produced from cream coming from clean centrifugal separators when held for six days at 70° F., five days at 75° F., and three days at 80° F.

Surface area.

Molds are aerobic and their growth in cream is confined to the surface. Here their growth may be so abundant that a mat is formed and the mold becomes visible. Cream showing visible mold has been rejected by some cream graders. If, however, the mat is removed or stirred into the cream, the cream may then be acceptable. In order to determine the relation that exists between surface area of cream and the amount of mycelia fragments found in the butter, the following series of experiments were made. A volume of fresh sweet cream obtained from a clean separator was divided into three equal volumes and each was placed into a container of different diameter. Cream in container 1 had a surface area of 12.6 square inches, container 2, 17.7 square inches, and container 3, 58.7 square inches. An equal volume of cream was added to each container every 12 hours to imitate the method of handling cream on the farm. Twelve trials were conducted. The time and temperature of holding was constant in all trials.

As shown in Table 2, the amount of mold in cream, temperature and time being alike, is dependent upon the surface area of the cream in the container that is exposed to air. In general, as seen from the average figures,

TABLE 2

The influence of the surface area of the cream exposed to air upon the amount of mold mycelia in the resulting butter

Ratio of positive fields	Container 1	Container 2	Container 3
Maximum	1.0	2.0	10.0
Average	1.0	1.3	4.0
Minimum	1.0	1.0	1.2
Surface area of cream in sq. inches	12.6	17.7	56.7
Ratio of surface area	1.0	1.4	4.5

the amount of mold in a given sample of cream is almost directly proportional to the amount of cream surface exposed to air.

Agitation of cream during storage.

The general practice on farms is to take the separated cream, cool it, and then thoroughly mix the fresh cool cream into the stored cream. It is assumed that agitation would incorporate air into the cream and break mycelia clumps that may exist, thereby making conditions favorable for mold growth. In order to obtain data on the influence of agitation on the amount of mycelia in butter, the following conditions were followed.

Fresh sweet cream from a clean separator was added to the stored cream at twelve-hour intervals in equal quantities to cream cans having the same diameter. The added cream in one container was thoroughly mixed with a hand stirrer on each addition with the accumulated cream. In the other container, the fresh cream was carefully layered at each addition on to the accumulated cream and not mixed with the accumulated cream. These duplicate containers were then held for the same length of time and at the same temperature, the cream churned, and the butter examined for mold mycelia. The results secured are presented in Table 3.

TABLE 3

Increase of mold mycelia due to agitation during accumulation of cream

Increase in per cent of positive fields	No. of trials	Per cent of samples
0	6	17.2
1 – 20	11	31.5
21 – 40	8	22.8
41 – 60	4	11.4
61 – 80	4	11.4
81 – 100	2	5.7
Total no. of trials	35	

Of the 35 duplicate trials that were made, 82 per cent showed that the agitation of the cream during its accumulation on the farm caused an increase in the number of mold mycelia fragments in the butter. The six

samples which showed no increase were samples that showed 100 per cent positive fields in both the non-agitated and agitated trials. Considering an arithmetical average, it was found that the agitated samples showed 67.5 per cent positive fields and the non-agitated 38.3 positive fields. No significant difference was apparent in the organoleptic qualities in the butter made from agitated and non-agitated cream. It does show that the stirring of cream favors the development of mold mycelia, but that it does not affect its grade.

Influence of the milk fat content of the cream upon the development of mycelia.

In unpublished results secured by Wildman, (3) he found, in the examination of cream as it was received by the creamery, that a trend was exhibited indicating that the amount of mycelia was greater in low testing cream than in high testing cream. This difference might have been due to the method of separation. However, in order to secure data, the following series of trials were conducted. Cream testing 45 per cent milk fat was secured from the separator. One-half of this cream was standardized with the skim milk obtained from this cream to a fat content of 15 per cent. The cream was then accumulated in identical containers and in the same manner held over varying time periods. In all, ten trials were made and the results are given in Table 4.

TABLE 4

Influence of milk fat content of cream upon mycelia development

Trial	Percentage of positive fields in the butter	
	15 per cent	45 per cent
1	6	4
2	98	75
3	100	56
4	99	100
5	10	4
6	66	15
7	10	8
8	100	86
9	24	14
10	76	72
Av.	59	37

The milk fat content of the cream was found to exert a slight influence upon mycelia development in cream, for in nine of the ten trials conducted, lower mycelia contents were obtained in the butter made from cream testing 45 per cent fat than from cream testing 15 per cent fat. The cream was obtained in both cases from the same source.

Limiting air supply to the cream surface.

The molds associated with cream and butter are aerobic and the bacteria causing cream deterioration are, for the most part, micro-aerophilic. Cream

held under conditions which limit the air supply to the cream surface would show very little or no mold growth, but would show chemical changes due to bacterial growth. In order to obtain data upon the above condition, four trials were conducted in which identical samples of cream were held for six and twelve days under limited and unlimited air supply. The limited air supply to the cream was secured by covering the surface of the cream to a depth of one-fourth inch with heavy mineral oil. The cream was held at 75–80° F. and the results obtained are given in Table 5.

TABLE 5

Influence of limited air supply upon the mold mycelia development in cream as measured in the resulting butter

Trial	Per cent positive fields	
	Limited air	Unlimited air
Six days		
1	0	63
2	0	81
3	0	50
4	0	72
Twelve days		
1	0	100
2	0	100
3	0	100
4	0	100

The difference found in grading the butter obtained from the cream held for six and twelve days with limited and unlimited air supply showed that there was no significant difference in quality due to the inhibition of the molds by limiting the air supply. This again illustrates that the molds in cream are not the causative factor in deterioration of the cream and that a limited air supply to the cream surface inhibits the development of molds on the surface of the cream.

II. THE INFLUENCE OF SOME MANUFACTURING METHODS ON THE MOLD MYCELIA CONTENT OF THE BUTTER

Butter differs in some respects from other dairy products as in the process of manufacture, the fat is washed so that there usually remains less than one per cent of the original curd from the cream. In the churning process, factors exist which may influence the amount of mold retained in the butter and the distribution of mold in the butter mass. Thus, the problem arises as to the effect that some of the manufacturing processes will have upon the mold mycelia content of the butter.

Distribution of mycelia in butter.

To obtain data on the distribution of mycelia in butter, samples were

taken from the churn at the gear end, drain end, and at the doors. Duplicate samples were taken and 100 fields were examined on each sample.

TABLE 6

Distribution of mycelia in a churning of butter

Churning	Gear end		Outlet end		Door 1		Door 2	
	Percentage of positive fields							
1	20	21	19	20	20	20	21	21
5	1	1	4	4	1	1	1	1
8	3	4	4	5	6	3	4	4
9	2	3	2	2	2	4	2	0

The data presented in Table 6, which are typical of the ten churnings examined, indicates that the mold mycelia in butter are uniformly distributed throughout the butter mass. Samples of low mycelia content are more significant than samples of high mycelia content, for the greater the amount of mycelia, the less the probable error in sampling and in distribution and it is for this reason that low mycelia content samples were selected.

The retention of the mycelia of cream in the butter made from that cream.

It has been demonstrated that but a small percentage of the bacteria found in the cream are retained in the butter, the majority being removed with the buttermilk and the wash water. No information was found in the literature indicating the retention of mold mycelia in the butter.

In order to secure data on the retention of mold mycelia in butter from cream, a method was devised to determine microscopically the amount of mycelia in cream. Samples of cream were obtained from commercial plants just prior to churning and of the finished butter. The number of samples examined were 121.

TABLE 7

Percentage retention of mold in butter as compared to the mold mycelia in cream

Percentage retention of mold in butter	No. of samples	Per cent of samples
Less than 10	29	24.0
11 – 20	26	21.5
21 – 30	25	20.7
31 – 40	20	16.5
41 – 50	12	10.0
51 – 60	6	5.0
61 – 70	3	2.5
Above 70	0	0.0

Table 7 indicates that of the molds found in cream, from less than ten per cent to as high as 70 per cent are retained in the butter, and that in 66.2 per cent of the samples the retention of mycelia was below 31 per cent. The amounts of mold mycelia in the butter varied from 0 to 100 per cent posi-

tive fields and no relation was found between the amount of mold in the cream and the per cent retained.

Under laboratory conditions, cream was inoculated with various strains of *Oospora lactis, Penicillium, Aspergillus,* and *Mucor;* the cream was not repasteurized after inoculation and was churned in a laboratory churn. The *Oospora lactis* strains were retained from nine to 42 per cent with an average of 23 per cent. The *Mucor, Aspergillus,* and *Penicillium* were found to be retained on the average of 10, 37, and 28 per cent, respectively.

These results indicate that the mold mycelia retention in butter of the mold mycelia in the cream is, in general, between 20 and 30 per cent.

Influence of size of butter granules.

Grimes (4), in studying factors affecting the retention of bacteria in butter, found that size of the butter granules were of importance, but in his work he made no mention of molds or mold mycelia. To obtain data upon this subject, samples were taken from the churn when the butter granules were about one-half the size of wheat grains and again when they were about twice as big as wheat grains. These samples were then analyzed for mold content using the plate and microscopic methods, and, as shown in Table 8, no significant difference was found in the mold plate count or in the microscopic mycelia count between underchurned or slightly overchurned butter.

TABLE 8

Influence of size of butter granules upon the mold content of butter

Trial	Granule size			
	One-half wheat grains		Twice wheat grains	
	Mold per ml.	Per cent positive fields	Mold per ml.	Per cent positive fields
1	45,000	96	46,000	96
3	3,100	17	3,160	18
5	600,000	458*	500,000	560*
7	480,000	402*	500,000	524*
9	50,000	88	50,000	85
11	8,000	8	9,000	10

* Count of mycelia per 100 fields.

The degree of cream neutralization upon the mold mycelia content of butter.

Wildman (5), in studies on mold in cream, found that he was able to agglutinate the mold present in cream using a methylene blue borax solution, the pH of the solution being 9.2. In the process of butter manufacture from sour cream, the cream is neutralized to a pH between 6.0 and 7.0. In order to obtain data as to the effect of pH upon the amount of mold mycelia, six trials were conducted using sour cream which was neutralized to a pH of approximately 6.0–7.0 and to a pH of approximately 8.0. These

creams were churned in a laboratory churn and then analyzed as to the per cent of fields positive for mold mycelia. The results which are given in Table 9 show that the pH limits to which cream is neutralized under commercial conditions do not influence the amounts of mold mycelia that are retained in the butter.

TABLE 9

Degree of cream neutralization upon the mold mycelia content of butter

Trial	Percentage of positive fields		
	Low pH	Medium pH	High pH
2	35	35	35
4	27	29	29
6	98	97	98

SUMMARY

1. Mold mycelia fragments in butter are an index of the length of time, temperature of storage, and the oxygen relationship of the cream from which the butter was made.

2. Mold mycelia in butter is not a direct index of the organoleptic quality of the cream from which the butter was made.

3. A higher percentage of mold mycelia is retained in the butter than bacteria. In general, the per cent retention is between 20 and 30 per cent.

4. Of the manufacturing operations studied none were found to significantly influence the mold mycelia content of the butter.

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HISTORY AND DEVELOPMENT OF THE STUDENTS' NATIONAL CONTEST IN THE JUDGING OF DAIRY PRODUCTS

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During the years which have intervened since the first intercollegiate students' dairy products judging contest held in 1916 in Springfield, Massachusetts, many records and data have been obtained regarding the dairy products judging contest, sponsored by the American Dairy Science Association.

Some of those data and records are herein assembled 1, that a permanent record of the more pertinent facts of the entire dairy products judging program may be had, and 2, that the changing personnel of coaches of dairy products judging teams and of dairy staff members may be informed concerning the development of dairy products judging.

To estimate the value of these students' national dairy products judging contests to the dairy industry is extremely difficult and, at best, figures would be only a matter of conjecture. Undoubtedly, the attainment of standards and ideals of perfection, both in the concrete and in the abstract, for butter, cheese, milk, and ice cream, have resulted from this contest, furnishing a clearing house of ideas and demonstrations to coaches and students alike.

COMMITTEES

The personnel of two committees of the American Dairy Science Association, the Committee for the Students' Dairy Products Judging Contest and the Committee for the Score Card for Dairy Products, should be noted particularly as being the guiding minds in the development of this contest. The personnel of these two committees throughout the period of the contests is presented in Tables 1 and 2. Thirteen different committees for the students' dairy products judging contest have been named.

The earlier committees of 1917, 1918, and 1919, chairmanned by Messrs. Lockwood, Thompson, and White, respectively, probably experienced the greatest difficulty in getting the contest under way. In his annual report before the American Dairy Science Association meeting, Mr. Lockwood[1] pointed out some of the problems confronting them:

> "The students' judging contest for dairy products was carried on under adverse conditions this year. . . . It cost more money to run our contest than to run the cattle judging contest. . . . It

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[1] J. DAIRY SC., 1: 425. 1917–18.

TABLE 1

Committees for the Students' Dairy Products Judging Contest, 1917–1938

1917[1]	*1918*[2]	*1919*[3]
W. P. B. Lockwood, Ch.	S. C. Thompson, Ch.	William White, Ch.
M. Mortensen	W. P. B. Lockwood	W. P. B. Lockwood
C. E. Lee	M. Mortensen	M. Mortensen
E. S. Guthrie	E. S. Guthrie	E. S. Guthrie
H. C. Mills	C. Larson	C. Larson
R. L. Lang	J. H. Frandsen	J. H. Frandsen
		S. C. Thompson
1920[4]	*1922*[5]	*1924*[6]
William White, Ch.	A. W. Rudnick, Ch.	H. A. Judkins, Ch.
W. P. B. Lockwood	J. R. Keithley	S. C. Thompson
A. W. Rudnick	J. A. Gamble	M. Mortensen
E. S. Guthrie	T. E. Wright	G. D. Turnbow
J. H. Frandsen	R. B. Stoltz	H. W. Gregory
H. F. Judkins	V. D. Chappell	
S. C. Thompson	E. S. Guthrie	
	S. C. Thompson	
1926[7]	*1927*[8]	*1932*[9]
R. B. Stoltz, Ch.	R. B. Stoltz, Ch.	R. B. Stoltz, Ch.
William White	William White	William White
M. Mortensen	H. W. Gregory	H. W. Gregory
G. D. Turnbow	G. D. Turnbow	P. A. Downs
H. W. Gregory	P. A. Downs	H. A. Bendixen
1934[9]	*1936*[10]	*1937*[11]
H. W. Gregory, Ch.	H. W. Gregory, Ch.	H. W. Gregory, Ch.
William White	R. B. Stoltz	G. M. Trout
P. A. Downs	William White	P. A. Downs
P. S. Lucas	P. A. Downs	William White
R. B. Stoltz, ex officio	R. W. Smith, Jr.	M. J. Mack
		1938[12]
		G. M. Trout, Ch.
		P. A. Downs
		William White
		M. J. Mack
		E. L. Fouts

[1] J. Dairy Sc., 1, 439. 1917–18.
[2] J. Dairy Sc., 2, 61. 1919.
[3] J. Dairy Sc., 2, 433. 1919.
[4] J. Dairy Sc., 3, 237. 1920.
[5] J. Dairy Sc., 5, 199. 1922.
[6] J. Dairy Sc., 7, 115. 309. 1924.
[7] J. Dairy Sc., 9, 503. 1926.
[8] Letters, R. B. Stoltz.
[9] J. Dairy Sc., 17, 340. 1934.
[10] J. Dairy Sc., 19, 223. 1936.
[11] J. Dairy Sc., 20, 65. 1937.
[12] J. Dairy Sc., 21, 57. 1938.

would seem that the judging of dairy products deserves pretty nearly as good a place as the judging of cattle, and we can get it; but the attitude is not towards it; and we will have to create this attitude. . . . When we find a high grade of butter, score it, discuss it, and carry back to our institutions the ideas and standards that we will have to meet in our production. . . . I believe manufacturers will put up a manufacturer's scholarship. Possibly a

TABLE 2

Committees for the Score Card for Dairy Products, 1918–1926

1918[1]	*1919*[2]	*1920*[3]
J. H. Frandsen, Ch.	J. H. Frandsen, Ch.	J. H. Frandsen, Ch.
H. B. Ellenberger	H. B. Ellenberger	H. B. Ellenberger
M. Mortensen	M. Mortensen	S. C. Thompson
S. C. Thompson	S. C. Thompson	B. W. Hammer
Ernest Kelly	Ernest Kelly	L. A. Rogers
W. P. B. Lockwood	W. P. B. Lockwood	Ernest Kelly
W. W. Fisk	W. W. Fisk	W. P. B. Lockwood
J. L. Sammis	J. L. Sammis	W. W. Fisk
		J. L. Sammis
		O. F. Hunziker
1922[4]	*1924*[5]	*1926*[6]
J. H. Frandsen, Ch.	J. H. Frandsen, Ch.	J. H. Frandsen, Ch.
H. B. Ellenberger	O. F. Hunziker	O. F. Hunziker
S. C. Thompson	L. A. Rogers	L. A. Rogers
B. W. Hammer	J. A. Gamble	J. A. Gamble
L. A. Rogers	W. P. B. Lockwood	W. P. B. Lockwood
J. A. Gamble		
Ernest Kelly		
W. P. B. Lockwood		
W. W. Fisk		
J. L. Sammis		
O. F. Hunziker		
A. C. Baer		

[1] J. Dairy Sc., 2, 61. 1919.
[2] J. Dairy Sc., 2, 433. 1919.
[3] J. Dairy Sc., 3, 237. 1920.
[4] J. Dairy Sc., 5, 199. 1922.
[5] J. Dairy Sc., 7, 309. 1924.
[6] J. Dairy Sc., 9, 503. 1926.

group of manufacturers, or interested men, may be persuaded to contribute a small amount each for its support."

Interest in the contest continually increased through the chairmanships of Messrs. White, Rudnick, Judkins, Stoltz, and Gregory. During the tenure of Professor Stoltz' committee, which served the period of longest duration, from 1926 to 1934, the visions of Professor Lockwood came to fruition in the form of more favorable conditions for scoring, incentives, financial support, and industrial fellowships. To Professors Stoltz' and Gregory's committee fell largely the responsibility of administering those research fellowships.

A survey of the committees presented in Table 1 shows the name of William White as serving the students' judging contest project for the longest period of time. Although his name does not appear on the committees named in 1922 and 1924, it must be noted that during this time he was superintendent of the national contest (Table 7).

The second committee whose action has had a profound influence upon the present scoring of dairy products and which has worked in collaboration with the Committee for the Students' Dairy Products Judging Contest is

TABLE 3

Colleges participating in the Students' National Dairy Products Judging Contest by years, 1916–1938

No.	College	'16	'17	'19	'20	'21	'22	'23	'24	'25	'26	'27	'28	'29	'30	'31	'32	'33	'34	'35	'36	'37	'38	No. of contests in which teams participated
		Year in which team was entered in contest																						
1	University of Arkansas					•												•	•	•				4
2	University of California								•		•				•									3
3	Connecticut State College	•						•			•	•			•	•	•	•	•	•	•	•	•	13
4	Cornell University	•		•				•									•	•	•	•	•	•	•	10
5	University of Georgia												•	•					•					3
6	University of Illinois														•	•	•	•	•	•	•	•	•	9
7	Iowa State College			•	•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	19
8	Kansas State College										•	•	•	•	•	•	•	•	•	•	•	•	•	13
9	University of Louisiana																•					•		2
10	Maryland State College			•	•			•									•				•		•	6
11	Massachusetts State College	•					•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	18
12	Michigan State College									•	•	•	•	•	•	•	•	•	•	•	•	•	•	14
13	University of Minnesota					•	•									•	•	•	•	•	•	•	•	10
14	Mississippi State College											•	•	•	•	•	•	•	•	•	•	•	•	12
15	University of Nebraska	•	•	•		•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	20
16	University of New Hampshire	•						•				•												3
17	New Mexico State College																						•	1
18	University of North Carolina										•	•	•											3
19	Ohio State University	•	•	•	•	•	•	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•	21
20	Oklahoma A. & M. College												•	•				•	•	•			•	6
21	Ontario Agricultural College														•	•						•	•	4
22	Oregon Agricultural College						•		•	•	•	•	•	•	•									8
23	Pennsylvania State College	•				•		•	•	•	•	•			•	•			•		•		•	12
24	Purdue University			•	•		•		•	•			•	•	•		•	•	•	•	•	•	•	15
25	Rutgers University															•					•			2
26	South Dakota State College	•	•	•	•	•	•			•	•	•	•	•			•	•	•	•		•	•	17
27	University of Tennessee											•	•	•	•				•	•	•	•	•	9
28	Texas Technological College																					•	•	2
29	University of Vermont	•														•	•						•	4
30	Virginia Polytechnic Institute													•		•								2
31	University of West Virginia					•	•		•	•	•	•	•	•	•	•	•	•	•				•	13
32	University of Wisconsin								•						•		•	•	•	•	•	•	•	9
	Total	9	3	7	5	8	9	7	10	10	13	15	14	15	17	16	18	17	19	17	18	17	23	287

Note: A contest was not held in 1918 because of the World War.

the Committee for the Score Card for Dairy Products. Of the six committees named from 1918 to 1926, Professor J. H. Frandsen has served as chairman throughout. A glance at the names of the personnel of these committees reveals the names of many leaders in the field of dairy manufacturing today, all of whom have contributed toward the development of the score cards now used in the scoring of butter, cheese, milk, and ice cream. The men who served on these committees at various times were: Messrs. Frandsen, Ellenberger, Mortensen, Thompson, Kelly, Lockwood, Fisk, Sammis, Hammer, Rogers, Hunziker, Gamble, and Baer.

NUMBER OF CONTESTS

The Students' National Contest in the Judging of Dairy Products has been held yearly since 1916, with the exception of the year 1918 when a contest was not sponsored because of the World War. From 1916 to 1938 inclusive, 22 separate contests have been held to which 32 colleges have sent 287 teams of three men each, a total of 861 contestants. In addition, approximately 225 alternates have accompanied these teams, and likewise have had the opportunity of witnessing the exposition with which the contest was affiliated, as well as studying the products assembled for judging.

COLLEGES REPRESENTED

The names of the colleges competing in the various contests are presented alphabetically in Table 3. An examination of the data in this table shows that 13 colleges have entered teams in the judging event in 10 or more

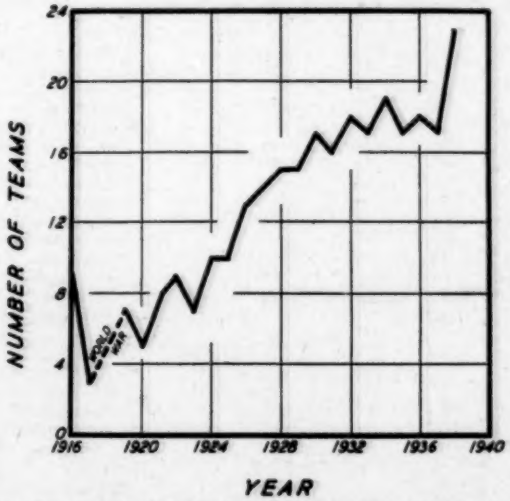

FIG. 1. The growth of the National Dairy Products Judging Contest.

of the 22 national contests. Teams representing Ohio State University have participated in 21 of the 22 contests, missing only one year, 1927. Nebraska, Iowa, Massachusetts, and South Dakota have been represented in all of the events but two, three, four, and five respectively. The growth of the Students' National Dairy Products Judging Contest with the years can best be seen in Figure 1. Here it will be noted that increasing interest, judging from the number of teams entered began to be manifest about 1926, continued to increase gradually until 1934, when, up to that time, the highest number, 19 teams, were entered in the contest. Four years later, 1938, 23 teams participated in the event.

Since 1930, when the Students' National Contest in the Judging of Dairy Products was sponsored jointly for the first time by the American Dairy Science Association and the Dairy Industries Supply Association, Inc., the team entries have averaged 18 per year.

During the 22 years since the inception of the judging project the Students' National Dairy Products Judging Contest has been held in 13 different cities located in the eastern half of the United States and has been affiliated with two separate organizations, namely, the National Dairy Association and the Dairy Industries Supply Association, Inc. The location, year, and number of colleges represented yearly are shown in Table 4.

TABLE 4

Location of the Students' National Dairy Products Judging Contest, 1916–1938

Number of contest	Year	Organization with whom affiliated	Location	No. of teams
1	1916	National Dairy Association	Springfield, Mass.	9
2	1917	" " "	Columbus, Ohio	3
3	1919	" " "	Chicago, Ill.	7
4	1920	" " "	Chicago, Ill.	5
5	1921	" " "	St. Paul, Minn.	8
6	1922	" " "	St. Paul, Minn.	9
7	1923	" " "	Syracuse, N. Y.	7
8	1924	" " "	Milwaukee, Wis.	10
9	1925	" " "	Indianapolis, Ind.	10
10	1926	" " "	Detroit, Mich.	13
11	1927	" " "	Memphis, Tenn.	14
12	1928	" " "	Memphis, Tenn.	15
13	1929	" " "	St. Louis, Mo.	15
14	1930	Dairy Industries Supply Association	Cleveland, Ohio	17
15	1931	" " " "	Atlantic City, N. J.	16
16	1932	" " " "	Detroit, Mich.	18
17	1933	" " " "	Chicago, Ill.	17
18	1934	" " " "	Cleveland, Ohio	19
19	1935	" " " "	St. Louis, Mo.	17
20	1936	" " " "	Atlantic City, N. J.	18
21	1937	" " " "	New Orleans, La.	17
22	1938	" " " "	Cleveland, Ohio	23

OFFICIAL JUDGES

The placing of the official scores and criticisms on the individual samples of butter, cheese, milk, and ice cream used in judging has been a real responsibility. Much of the success of a dairy products judging program is dependent upon the establishment of standards, having a continuity from year to year. The standards for flavors, bodies, textures, and so on established one year in a contest furnished mental standards to the coach for training students the following year. Therefore, the placing of scores upon dairy products used in the contest has had a wide and profound influence in raising the level of quality of dairy products nationally.

The task of selecting qualified judges has fallen largely to Mr. William White, Bureau of Dairying, United States Department of Agriculture, who has been superintendent of the National Dairy Products Judging Contest since 1925. The judges selected to place the official scores on the various products are listed in Table 5. Only the names of the judges since and

TABLE 5

The judges who placed the official scores and criticisms on the samples of butter, cheese, milk, and ice cream, in the National Dairy Products Judging Contest since 1926

Year	Butter	Cheese	Milk	Ice cream
1926	L. E. Gaylord H. W. Gregory	C. W. Freyhoffer E. L. Aderhold	R. J. Posson C. E. Clement	H. F. Judkins C. S. Trimble
1927	L. S. Edwards G. A. Gilbert	G. N. Tobey G. A. Gilbert	R. J. Posson	H. F. Judkins
1928	G. A. Gilbert L. S. Edwards	G. A. Gilbert G. N. Tobey L. H. Marlatt	C. J. Babcock R. W. Bell	W. H. E. Reid
1929	H. D. Reynolds L. S. Edwards	H. L. Wilson William White	C. J. Babcock C. S. Leete	W. H. E. Reid P. H. Tracy
1930	O. A. Storvick H. D. Reynolds	H. L. Wilson J. W. Moore	Ernest Kelly C. J. Babcock	A. C. Dahlberg A. D. Burke
1931	L. D. Reekie L. S. Edwards	H. L. Wilson W. E. Ayers	C. J. Babcock F. M. Grant	A. C. Dahlberg A. D. Burke
1932	C. E. Eckles	H. L. Wilson	C. J. Babcock	A. C. Dahlberg
1933	C. L. Pier	H. L. Wilson	C. J. Babcock	A. C. Dahlberg
1934	L. S. Edwards	H. L. Wilson	C. J. Babcock	A. C. Dahlberg
1935	L. S. Edwards	H. L. Wilson	C. J. Babcock	A. C. Dahlberg
1936	L. S. Edwards	H. L. Wilson	C. J. Babcock	A. C. Dahlberg
1937	L. S. Edwards	H. L. Wilson	C. J. Babcock	A. C. Dahlberg
1938	L. S. Edwards	H. L. Wilson	C. J. Babcock	A. C. Dahlberg

including 1926, the year in which ice cream was first a part of the judging program, are included. Perhaps the most striking feature of this table is the recurrence of the name of the official judge of a product year after year. The use of the same judge for a number of years, especially in the scoring of a product in which the national standards are not so well established, would seem to be the part of wisdom. By this procedure, the scoring of cheese, milk, and ice cream has become more standardized than formerly. The comparative uniformity of butter scoring throughout the country has been recognized for some time.

Since 1932 the official scoring of each product has been checked by two coach judges appointed by the Dairy Products Judging Committee. The names of the coach judges are presented in Table 6. These coach judges working independently rescored the samples. If a comparison of scores revealed a total lack of agreement between the official judge and the coach judge as to the evaluation of scores or criticisms, then the sample in question was not used in the contest. Each year eight coach judges, two for each product, have thus assisted in the official judging since the introduction of this system.

TABLE 5a

Identification of dairy products judges

Ice Cream

A. D. Burke, Alabama Polytechnic Institute, Auburn, Ala.
A. C. Dahlberg, N. Y. State Agr. Expt. Sta., Geneva, N. Y.
H. F. Judkins, Eastern States Dairies, Springfield, Mass.
W. H. E. Reid, University of Missouri, Columbia, Mo.
P. H. Tracy, University of Illinois, Urbana, Ill.
C. S. Trimble, Bureau of Dairy Industry, Washington, D. C.

Butter

L. S. Edwards, Bureau of Dairy Industry, Nashville, Tenn.
L. E. Gaylord, Bureau of Agricultural Economics, Washington, D. C.
G. A. Gilbert, U. S. Food Products Inspector, Chicago, Ill.
H. W. Gregory, Purdue University, Lafayette, Ind.
H. D. Reynolds, Mason City, Iowa.
O. A. Storvick, Albert Lea, Minn.
L. D. Reekie, Bureau of Agricultural Economics, New York City.
C. E. Eckles, Bureau of Agricultural Economics, Washington, D. C.
C. L. Pier, Bureau of Agricultural Economics, Chicago, Ill.

Cheese

E. L. Aderhold, Neenah, Wis.
W. E. Ayers, Cornell University, Ithaca, N. Y.
C. W. Freyhoffer, Bureau of Agricultural Economics, Washington, D. C.
G. A. Gilbert, U. S. Food Products Inspector, Chicago, Ill.
L. H. Marlatt, Cheese Specialist, Athens, Ga.
J. W. Moore, Dept. of Agr. and Markets, Madison, Wis.
G. N. Tobey, Cheese Specialist, Knoxville, Tenn.
Wm. White, Bureau of Dairy Industry, Washington, D. C.
H. L. Wilson, Bureau of Dairy Industry, Washington, D. C.

Milk

C. J. Babcock, Bureau of Dairy Industry, Washington, D. C.
R. J. Bell, U. S. Dept. of Agri., Washington, D. C.
C. E. Clement, Bureau of Dairy Industry, Washington, D. C.
Ernest Kelly, Bureau of Dairy Industry, Washington, D. C.
C. S. Leete, Bureau of Dairy Industry, Washington, D. C.
R. J. Posson, Bureau of Dairy Industry, Washington, D. C.
F. M. Grant, Bureau of Dairy Industry, Washington, D. C.

SUPERINTENDENTS OF CONTESTS

From the inception of student dairy products judging to the present time only two men have superintended the contest, as shown in Table 7. These

TABLE 6

The coach judges who have assisted in the official scoring of the samples of butter, cheese, milk, and ice cream used in the National Dairy Products Judging Contest

Year	Butter	Cheese	Milk	Ice Cream
1932	E. S. Guthrie R. E. Roberts	W. H. Martin E. F. Goss	G. M. Trout L. M. Thurston	P. H. Tracy R. W. Smith
1933	L. C. Thomsen F. H. Herzer	P. A. Downs G. M. Trout	L. H. Burgwald H. G. Lindquist	C. A. Iverson E. L. Fouts
1934	M. Mortensen R. E. Roberts	F. W. Bennett C. A. Jacobson	E. O. Anderson S. T. Coulter	W. H. Martin J. H. Erb
1935	S. L. Tuckey E. S. Guthrie	R. E. Roberts S. T. Coulter	W. H. Martin E. L. Fouts	F. H. Herzer P. S. Lucas
1936	L. C. Thomsen C. M. Mecham	H. G. Lindquist W. H. Sproule	P. H. Tracy F. J. Doan	L. R. Dowd P. A. Downs
1937	N. E. Fabricius R. E. Roberts	S. T. Coulter S. L. Tuckey	T. B. Harrison H. G. Lindquist	F. H. Herzer G. M. Trout
1938	E. O. Herreid S. T. Coulter	L. C. Thomsen K. R. Renner	I. A. Gould F. J. Doan	W. H. Martin N. E. Fabricius

honors have been shared by Mr. S. C. Thompson and Mr. William White of the Bureau of Dairy Industry, United States Department of Agriculture. Mr. S. C. Thompson was the superintendent for the first two years; Mr. White for the next two; and then Mr. Thompson was superintendent again until his death in 1925. Since then, for 13 years, Mr. William White, Senior Dairy Manufacturing Specialist, Bureau of Dairy Industry, United States Department of Agriculture, has been the superintendent of the contest.

TABLE 7

Superintendents of National Dairy Products Judging Contest

Year	Name	Year	Name
1916	S. C. Thompson	1928	William White
1917	" " "	1929	" "
1919	William White	1930	" "
1920	" "	1931	" "
1921	S. C. Thompson	1932	" "
1922	" " "	1933	" "
1923	" " "	1934	" "
1924	" " "	1935	" "
1925	William White	1936	" "
1926	" "	1937	" "
1927	" "	1938	" "

RANKING OF COLLEGES IN JUDGING DAIRY PRODUCTS

A summary of the ranking of the colleges in the judging of dairy products is presented in Table 8. Since 1926, four dairy products, butter, cheese, milk,

TABLE 8

Summary of ranking colleges in the judging of dairy products

Year	Colleges winning first place in dairy products judging, by years					No. teams per year
	Butter	Cheese	Milk	Ice Cream	All products	
1916	Pennsylvania*	_____	_____	_____	_____	9
1917	S. Dakota	Nebraska	S. Dakota	**	***	3
1918	****	.....	.....	.....	.....	___
1919	Iowa	Ohio	S. Dakota	_____	S. Dakota	7
1920	S. Dakota	Ohio	Ohio	_____	Ohio	5
1921	Ohio	Ohio	Ohio	_____	Ohio	8
1922	S. Dakota	Ohio	Massachusetts	_____	Ohio	9
1923	Pennsylvania	Ohio	Ohio	_____	Pennsylvania	7
1924	Iowa	Purdue	Massachusetts	_____	Iowa	10
1925	S. Dakota	Iowa	W. Virginia	_____	Iowa	10
1926	Oregon	S. Dakota	Iowa	Iowa	Iowa	13
1927	Iowa	Tennessee	Kansas	Massachusetts	Iowa	14
1928	Iowa	W. Virginia	S. Dakota	Ohio	Iowa	15
1929	Oregon	Ohio	Ohio	Iowa	Ohio	15
1930	Mississippi	Kansas	W. Virginia	Illinois	Kansas	17
1931	Mississippi	Michigan	Iowa	Vermont	Iowa	16
1932	Purdue	Michigan	Purdue	Mississippi	Mississippi	18
1933	S. Dakota	Wisconsin	Illinois	Massachusetts	Ohio	17
1934	Minnesota	Iowa	Mississippi	Ohio	Ohio	19
1935	Tennessee	Mississippi	Tennessee	Nebraska	Mississippi	17
1936	Iowa	Tennessee	Ohio	Cornell	Ohio	18
1937	Nebraska	Minnesota	S. Dakota	Ohio	Ohio	17
1938	Iowa	Cornell	Ohio	Cornell	Cornell	23

* Butter only judged in 1916.
** Ice Cream not included until 1926.
*** No rating for all products.
**** No contest because of World War.

and ice cream have been judged, ice cream being included that year for the first time. Butter only was judged in the first contest in 1916, while cheese and milk were first included in the second scoring contest, in 1917.

Of the 32 colleges which have been represented in the judging event, only seven, namely, Ohio, Iowa, Mississippi, South Dakota, Pennsylvania, Kansas, and Cornell, have won sweepstakes honors one or more times. Ohio State University has won first eight times; Iowa State College, six times, five years consecutively from 1924 to 1928 inclusive; Mississippi State College, twice; and the State Colleges of South Dakota, Pennsylvania, Kansas, and Cornell University each once; Ohio State University teams have won the sweepstakes position 38.1 per cent of the contests entered, 21 times, while Iowa State teams have won 31.6 per cent of the contests entered, 19 times.

In the judging of butter, Iowa has won first place six times to South Dakota's five. Mississippi, Oregon, and Pennsylvania, each have won the butter judging contest twice, while Ohio, Purdue, Minnesota, Tennessee, and Nebraska each have won the contest once.

Teams representing Ohio State University have won the cheese judging contest six times, winning five years consecutively from 1919 to 1923 inclusive. Iowa, Michigan, and Tennessee each have won twice, while Nebraska, Purdue,

South Dakota, West Virginia, Kansas, Wisconsin, Mississippi, Minnesota, and Cornell have enjoyed the honor once.

Milk judging sweepstakes have gone to Ohio six times; to South Dakota four; to Massachusetts, West Virginia, and Iowa, twice; and to Kansas, Purdue, Illinois, Mississippi, and Tennessee once.

In judging ice cream, the Ohio State University teams have won first place three times of the 13 years in which ice cream judging was included in the contest. Iowa, Massachusetts, and Cornell each have won twice, while Illinois, Vermont, Mississippi and Nebraska each have won once.

AFFILIATION WITH THE DAIRY INDUSTRIES SUPPLY ASSOCIATION, INC.

The year 1930 marked the beginning of a new era in the student judging of dairy products for in that year for the first time the National Students' Dairy Products Judging Contest was sponsored jointly by the American Dairy Science Association and the Dairy Industries Supply Association, Inc., and was held in connection with the Dairy Industries Exposition. Early in that year representatives of the students' dairy products judging committee, of which Professor Stoltz was chairman, met with representatives of the committee of the Dairy Industries Supply Association, Mr. Roberts Everett, Executive Vice-President, and Mr. C. Earl Breece, Secretary, to evolve a plan whereby each organization might be more ably served by a joint dairy products judging program.

As a result of the program projected, nine national students' dairy products judging events have now been held jointly by these two associations in six different cities throughout the eastern half of the United States. The consistently high team participation regardless of the location of the contest, as shown in Table 4 and Figure 1, attest to the interest awakened in students' dairy products judging through adequate incentives, which were provided as a result of the long time program outlined by the committees of these two associations.

INCENTIVES

From 1930 to 1938 inclusive, 162 teams of three men each, a total of 486 team members, plus approximately 125 alternates participated in the judging event activities. Regardless of the location of the contest or of the general business condition of the country, no less than a low of 16 teams and a high of 23 teams, with an average of 18 teams, competed yearly.

A study of these contests indicates quite clearly that at least four incentives have had an influence upon the maintenance of this high team participation. These are 1, the dairy manufacturing student had an opportunity of visiting the Dairy Industries Exposition in addition to the contest; 2, financial aid made possible greater facilities, comfort, and more pleasing environment for judging dairy products; and 3, the honors evening banquet devoted

entirely to dairy manufacturing students furnished a setting whereby the student could get a vision of, or the sense of belonging to, the dairy industry; and 4, awarding of the coveted industrial fellowships made possible further educational opportunities.

The Dairy Industries Supply Association has made possible largely these incentives through its hearty cooperation and financial support. During the past nine years this association has awarded 51 fellowship grants totaling $34,200.00, as shown in Table 9, to 51 students showing proficiency in scholarship as well as in the judging of dairy products. In addition, the Association has borne in large part the expense connected with the actual products judging as well as the honors evening banquet.

TABLE 9

Fellowship grants of the Dairy and Ice Cream Machinery and Supplies Association, Inc., 1930–1938

Year	Number of grants	Value of each	Total
1930	6	$750.00	$ 4,500.00
1931	6	750.00	4,500.00
1932	6	750.00	4,500.00
1933	6	750.00	4,500.00
1934	6	600.00	3,600.00
1935	6	600.00	3,600.00
1936	6	600.00	3,600.00
1937	6	600.00	3,600.00
1938	3	600.00	1,800.00
Total	51		$34,200.00

COLLEGES COMPETING 1930–1938, INCLUSIVE

A total of 30 different colleges have participated in the national dairy products judging contest since 1930. Nine colleges, Connecticut, Iowa, Illinois, Kansas, Massachusetts, Michigan, Mississippi, Nebraska, and Ohio have entered teams each year, while six other colleges have entered teams six or more years during the nine years of the jointly sponsored contest.

FELLOWSHIP WINNERS

A roster of the colleges winning one or more of the Dairy Industries Supply Association Fellowships contains the names of 17 colleges sharing those honors from 1930 to 1938, inclusive. These colleges are scattered over 16 states and the Province of Ontario, Canada.

Colleges from Ohio, Mississippi, and Minnesota have been awarded seven, six, and five fellowships respectively, while those from Iowa, Kansas, Michigan, and Nebraska each have been awarded four fellowships. Cornell has won three, while Connecticut, Illinois, Massachusetts, South Dakota, and

Tennessee each have won two fellowships. Arkansas, Ontario, Purdue, and Vermont each have won one fellowship.

From 1930 to 1933 inclusive the fellowships were awarded to the ranking individuals in the judging of dairy products. Since 1934, the fellowships have been awarded to the schools leading in judging, and have been granted to the team member or alternate selected, largely on the basis of scholarships, by a committee from that school.

The research under these grants has been carried out in 14 state colleges or universities, namely, California, Connecticut, Cornell, Iowa, Illinois, Kansas, Massachusetts, Michigan, Minnesota, Nebraska, Ohio, Pennsylvania, Purdue, and Wisconsin. Considering the 17 schools winning the fellowships with the 14 schools to which Fellows have been assigned for graduate study, a total of 20 different institutions have felt the influence of these grants at one time or another. Several institutions have won both a fellowship and have been assigned a fellow from another institution the same year.

ULTIMATE SUCCESS OF DAIRY PRODUCTS JUDGING CONTESTS

Based upon the number of contestants in dairy products judging during the past decade, the National Dairy Products Judging Contest would seem to have succeeded beyond the dream of those responsible for its initiation. Yet numbers alone probably are a poor criteria by which to evaluate the success of the project. Rather the consciousness in dairy products judging awakened by these contests and a recognition of standards of quality throughout the country would be a more accurate measure of its worth. Today, in several states, the judging of dairy products is carried into the Smith-Hughes schools, where high school boys and girls are becoming conscious of quality in dairy products. If the National Dairy Products Judging Contest has furnished the incentive for training leaders to carry on such a phase of the quality program the time and effort have been well expended.

American Dairy Science Association Announcements

THIRTY-FOURTH ANNUAL MEETING

Plans are being completed for the housing and entertainment of the members attending the 34th Annual Meeting of the American Dairy Science Association to be held at Pullman, Washington, and Moscow, Idaho, June 27–30, 1939. Questionnaires are being sent out giving an opportunity to all parties to make the type of reservations desired by them. Accommodations of every kind will be available, including modern college dormitories, hotels, tourist cabins. To facilitate arrangements, it is requested that reservations for accommodations be returned before June 1.

THE COMPLETE PROGRAM WILL BE FOUND IN THE JUNE NUMBER OF THE JOURNAL

A large attendance is expected. Bring the family. Free guest tickets will be provided for members to play golf in Pullman and in Moscow. Tennis courts and swimming pools will be open to our guests. Fishing should be good in the not too distant mountain streams for the friends of Isaac Walton who wish to relax after the meetings. Plan now for a glorious trip to the beautiful Pacific Northwest. Paved highways all the way out. Grand scenery, cool nights. See the great Coulee Dam, large cooperative plants, fine herds, Mt. Rainier and other National Parks. Westward ho!

The distance from Pullman to Moscow is 9 miles on a good highway. It takes less than 15 minutes to drive between the two institutions.

CANADIAN SOCIETY OF TECHNICAL AGRICULTURISTS

Mr. H. L. Trueman, Secretary of the Canadian Society of Technical Agriculturists, informs us that the C. S. T. A. Meeting and the Annual Convention is to be held in Vancouver, British Columbia, from June 19–22. This makes it possible for those interested to attend both conventions.

LETTER FROM THE SECRETARY

Members:

Are you planning to attend the annual meeting in June? Many members and subscribers are making plans now to kill two birds with one stone.

First—Attend the meeting and rub shoulders with other dairymen who are attempting to do the same thing for which we are all striving. Recharge the storage battery to retain enthusiasm. Get new ideas. Go home and do a

better job. Our progress in the future will depend more and more upon the new developments and more efficient short cuts than ever before.

Second—Give yourself and your wife or family a peep at the great U. S. You have never been any place if you haven't seen the Great Northwest.

It's not my intention to oversell you, but before you live another year you should have the privilege of associating with the people of the great United States in their native, outspoken, hospitable and courteous way. You will want to see the beautiful Western Country, the mountains, and the National Parks. Most people find it necessary to sacrifice something at home to see these things. It's worth it to most of those who go. The cost is low.

You need a change, your wife needs a change of scenery and your children are the correct age to be educated.

Some will choose to drive; others will go on the train. The round trip rail fare from Chicago, including sleepers, is from $80.40 to $110.55. The Northern Pacific Railway has been selected as the official route so that those going by train may leave Chicago traveling together from Thursday, June 22nd, until Monday, June 26th.

I have been told that there is good fishing in the Northwest. Usually, however, one is so busy seeing things that one doesn't have time to fish.

We trust that many families will be able to take in this wonderful trip.

Sincerely yours,
R. B. STOLTZ, Sec'y-Treas.

NEW MEMBERS FOR 1939—BY STATES

APPLICATIONS RECEIVED BETWEEN MARCH 6–APRIL 10, 1939

ARKANSAS

Gregg, V. L., *Chairman, State Membership Committee.* (Total to date—2.)
Broadhurst, Lee, Rogers, Ark.

CALIFORNIA

Roadhouse, C. L., *Chairman, State Membership Committee.* (Total to date—12.)
Denny, James M., San Francisco, Calif.
Kohler, Roland, Los Angeles, Calif.
Manning, Paul D. V., San Francisco, Calif. (nominated by Turnbow).

CONNECTICUT

Mann, A. I., *Chairman, State Membership Committee.* (Total to date—2.)
Atwood, Grover C., Storrs, Conn. (Student Affiliate) (by White).

DISTRICT OF COLUMBIA

LeFevre, P. E., *Chairman, Membership Committee.* (Total to date—2.)

GEORGIA

Bennett, F. W., *Chairman, State Membership Committee.* (Total to date—6.)
Frey, E. W., Douglas, Ga.
Hodgson, Harold B., Athens, Ga.

IDAHO

Fourt, D. L., *Chairman, State Membership Committee.* (Total to date—1.)
Wise, Arthur, Salmon, Idaho.

ILLINOIS

Kuhlman, A. F., *Chairman, State Membership Committee.* (Total to date—13.)
Eisenstein, Norman, Chicago, Ill. (by Ruehe).
Greene, Howard T., Genesee Depot, Wisc. (by Yapp).
Harshbarger, Kenneth E., Urbana, Ill.
Hemb, D. M., Chicago, Ill. (by Ruehe).
Ingle, J. D., Chicago, Ill. (by Parsons).
Keeffer, Kyle W., Aurora, Ill. (by Ruehe).
Kuhlman, A. F., Urbana, Ill.
Scott, E. C., Chicago, Ill. (by Parsons).
Edman, George J., Urbana, Ill. (Stud. Aff.) (by Ruehe).

INDIANA

Wilbur, J. W., *Chairman, State Membership Committee.* (Total to date—29.)
Epple, William F., Lafayette, Ind.
Gannon, E. A., W. Lafayette, Ind.
Logan, Paul S., Lafayette, Ind.

IOWA

Johnston, Floyd, *Chairman, State Membership Committee.* (Total to date—23.)
Anderson, Donald E., Ames, Iowa (by Iverson).

Baird, Phil, Lohrville, Iowa (by Hammer).
Berry, John C., Ames, Iowa.
Cannon, Robert Y., Ames, Iowa.
Conner, J. K., Mandan, N. Dak. (by Iverson).
Cromer, Paul C., Emmetsburg, Iowa.
Eaton, Hamilton, Ames, Iowa.
Emerson, John, Emmetsburg, Iowa.
Finch, Lindley, Dallas Center, Iowa.
Ingels, John W., Waverly, Iowa.
Jaekels, Dallas C., Ames, Iowa.
Knapp, Seaman A., Ames, Iowa (by Iverson).
Lynch, Arthur D., St. Louis, Mo.
Medin, Carl D., Mason City, Iowa.
Micheel, Vernon L., Ames, Iowa.
Thomas, Dr. B. H., Ames, Iowa.
Weaver, Russell C., Mason City, Iowa.
Willey, R. C., Mason City, Iowa.
Underbjerg, Gravers, Ames, Iowa.

KANSAS

Linn, J. W., *Chairman, State Membership Committee.* (Total to date—1.)

KENTUCKY

Ely, Fordyce, *Chairman, State Membership Committee.* (Total to date—4.)
Burnette, W. P., Mayfield, Ky.
Foster, J. D., Lexington, Ky.
Smathers, Jas. B., Lexington, Ky.
Wilson, Philip, Lexington, Ky.

LOUISIANA

Lush, R. H., *Chairman, State Membership Committee.* (Total to date—2.)
Fahrig, Chris G., Taft, La.

MARYLAND

England, C. W., *Chairman, State Membership Committee.* (Total to date—7.)

MASSACHUSETTS

Frandsen, J. H., *Chairman, State Membership Committee.* (Total to date—5.)
Smith, Albert W., Springfield, Mass.

MICHIGAN

Weaver, Earl, *Chairman, State Membership Committee.* (Total to date—30.)
Johnson, George K., East Lansing, Mich.

MINNESOTA

Macy, H., *Chairman, State Membership Committee.* (Total to date—25.)
Ahlstrand, Eric R., St. Paul, Minn.
Bergford, Harold L., Moorhead, Minn.
Brereton, John C., St. Paul, Minn.
Collis, Harold W., St. Paul, Minn.
Hogenson, Raymond B., St. Paul, Minn. (by Coulter).
Mattson, Walfrid T., Hibbing, Minn.
Shaw, Joseph C., St. Paul, Minn.

MISSISSIPPI

Herzer, F. H., *Chairman, State Membership Committee.* (Total to date—3.)
Mitchell, S. B., Uniontown, Ala.

MISSOURI

Herman, H. A., *Chairman, State Membership Committee.* (Total to date—9.)
Decker, Clinton W., Columbia, Mo. (Stud. Aff.).
Garrison, Earl R., Columbia, Mo.
Hall, W. C., Columbia, Mo.
Hunt, Edw. S., Tonganoxie, Kans.
Mixner, John P., Columbia, Mo.
Skinner, G. R., Bonne Terre, Mo.

MONTANA

Nelson, J. A., *Chairman, State Membership Committee.* (Total to date—9.)
Bates, Richard M., Great Falls, Mont.
Horkan, George, Bozeman, Mont.
Kopland, D. V., Huntley, Mont.

NEW HAMPSHIRE

Morrow, K. S., *Chairman, State Membership Committee.* (Total to date—1.)
Hall, Clyde N., Durham, N. H.

NEW YORK

Salisbury, G. W., *Chairman, State Membership Committee.* (Total to date—27.)
Albrectsen, Raymond, Ithaca, N. Y.
Bard, James M., Thornwood, N. Y.
Cairns, G. M., Ithaca, N. Y.
Doob, Hugo, Jr., Ithaca, N. Y. (by Holland).
Duck, Ira B., Jr., New York, N. Y.
Emasiri, Saluey, Ithaca, N. Y. (by Holland).
Gunsalus, Irwin C., Ithaca, N. Y. (by Holland).
Harrison, Edwin, Ithaca, N. Y.
Kahlenberg, Orme J., Bainbridge, N. Y. (by Noll).
Landsburg, Kenneth, New York, N. Y.
Lu, Louis Kao Hui, Ithaca, N. Y. (by Holland).
Robinson, L. W., Alfred, N. Y. (by Myers).
Santa Maria, Anthony A., Richmond Hill, N. Y. (by Herrington).
Stewart, Aubrey P., Ithaca, N. Y. (by Holland).
Botwinik, Leonard, Ithaca, N. Y. (Stud. Aff.).
Shapiro, Norman, Ithaca, N. Y. (Stud. Aff.).

OHIO

Salisbury, S. M., *Chairman, State Membership Committee.* (Total to date—45.)
Bishop, Robt. W., Greenville, O.
Boone, W. J., Marysville, O. (by Titus).
Grinnell, Cornelius, Yellow Springs, O.
Groves, Elden R., Spencer, Ind.
Haas, Norman F., Orrville, O.
Kahler, Karl M., Chagrin Falls, O.
Little, Ralph B., Princeton, N. J. (by Sutton).
Lohmeyer, Carl, Swedesboro, N. J.
Nadelin, Eugen Paul, Wooster, O.

Starbuck, Raymond R., Rio Grande, O.
Thompson, John C., New York, N. Y.
Wagner, Wm., Canal Fulton, O.
Wehr, Wade N., Youngstown, O.
Wisler, A. G., Sharon Center, O.
Babcock, Wayne, Toledo, Ohio (Stud. Aff.) (by Stoltz).
Summe, John J., Columbus, O. (Stud. Aff.) (by Stoltz).
Thomas, Elmer L., Columbus, O. (Stud. Aff.) (by Stoltz).

OREGON

Wilster, G. H., *Chairman, State Membership Committee.* (Total to date—4.)
Fletcher, Norman, Coquille, Ore.
Haag, J. R., Corvallis, Ore.
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Prussian Dairy Research Institute, Kiel, Germany

State Agricultural Colleges and Experiment Stations

The Royal Technical College, Copenhagen, Denmark

United States Department of Agriculture

ABSTRACTS OF LITERATURE

BREEDING

216. Idaho Bull Associations. D. L. Fourt and Ivan H. Loughary. Idaho Agr. Exp. Sta. Bull. 223, Nov., 1938.

The bulletin is a detailed report based upon data assembled on 48 bull associations organized in Idaho between 1919 and 1938. Based upon the experiences of the Idaho associations the benefits of bull associations such as; better bulls for less money, less maintenance cost, longer service per bull, standard breeding program, better quality of progeny, and stimulation of interest in dairying, are carefully discussed and evaluated.

A thorough presentation is made of the problems of organization and management including financing the association, loss of members, blocks, and bulls, quality of bulls, efficiency of bulls, feeding and management of bulls, records, maintaining interest, disease control and Constitution and By-Laws. D.R.T.

CHEESE

217. Pasteurization of Milk for Cheese-Making. J. G. Davis. Dairy Ind. *4:* 2, 43, 1939.

Although the trend toward pasteurization of milk for cheese making is quite recent the possibilities of best treatment have been considered for at least forty-five years.

Consideration is given to each of the apparent advantages and disadvantages of pasteurization as it is related to the cheese industry and stresses the advantages of bacterial destruction, uniformity of product and increased yield.

Little difficulty has been experienced in Cheddar cheese manufacture when pasteurization has been employed but some difficulty has been encountered by the Swiss cheese manufacturers in America. The European makers have been very successful. The most trouble is experienced by the manufacture of semi-soft and soft varieties. Many experts have stated that it is impossible to make really good cheese of this type with pasteurized milk. If true, this may be ascribed to the more important roles of the general flora and enzymes of normal unheated milk. D.V.J.

DISEASE

218. An Evaluation of Some of the Tests Used in Detecting Mastitis in Dairy Cattle. A. C. Fay, Director of Laboratories, H. P. Hood & Sons, Inc., Boston, Mass. J. of Milk Techn. *1:* 4, 38, 1938.

The paper discusses only the chronic form of mastitis. The paper pre-

sents an analysis of data from various sources giving a comparison of various "field" and "laboratory" tests for detecting mastitis.

The analysis shows that the percentage of agreement of the various tests with the isolation of streptococci to be in the following order.

1. Microscopic examination of a smear from incubated milk 87%.
2. The Hotis test 63%.
3. Enumeration of leucocytes 55%.
4. Manual palpation of the udder for detecting fibriotic tissue 40%.
5. The catalase test 39%.
6. The chloride test 38%.
7. The brom-thymol-blue test 36%.
8. The strip-cup test 26%.
9. Microscopic examination for streptococci in the unincubated milk 14%, and
10. Abnormal (purulent or watery) milk 8%.

These tests fall into three rather well defined classes:

1. The microscopic examination of the incubated milk which is fairly dependable when applied to known positive cases of mastitis and also to milk from cows known to be free from the disease.

2. The Hotis test, the enumeration of leucocytes, the examination of the udder for fibrosis, the catalase test, and the chloride test rarely give a false test on a positive sample, but milk from one third to two thirds of the cows known to be free from the disease will give a false positive test which does not necessarily indicate that the disease exists.

3. The brom-thymol-blue test, the strip-cup test, the microscopic examination of the direct smear for streptococci, and the observance of purulent, watery abnormal milk are characterized by failing to point out a sufficiently high percentage of the known positive cases to warrant their use as the sole means of identifying mastitis cows for segregation from the herd. L.H.B.

219. Die Feststellung der Abortus-Bang-Infektion (Bruzellose) des Rindes mit Hilfe serologischer Verfahren. II. Mitteilung: Die Schnellund Langsamagglutination mit Blut und Milch. (Serological Methods of Diagnosing Brucellosis in Cattle.) SEELEMANN UND WOLF. Zschr. Infektkr. Haustiere *54:* (½) 23–44.

Most of this report is on the evaluation of three methods of diagnosis—(1) the rapid agglutination test, (2) the slow agglutination test and, (3) the flocculation reaction (Meinickreaction). Although most of the tests were made on blood and blood serum, milk and milk serum were used in some instances. A rather long discussion of the literature is included.

The conclusions are briefly, that the rapid agglutination test with serum, when used in the laboratory, is a very sensitive and satisfactory method of diagnosis, but not so satisfactory outside the laboratory. The rapid test

was usually read as positive in about one minute and as negative in five minutes. This test was found to agree fairly well with the flocculation test. The flocculation test is rather slow and may be improved by warming. When the tube test is taken as a standard the rapid test is somewhat more accurate than the flocculation reaction. There is a slightly closer correlation between the tests when milk constituents are used instead of blood.

A combination of tests appears to be of value in determining the diagnosis. When the rapid test was complete and the tube test exhibited a titre of 50 or more, the test was read as positive. When the rapid test was complete, the tube test was below 50 and the flocculation test positive, the reading was still considered positive. But when the rapid test was complete, the tube test below 50, and the flocculation negative, the case was reported as negative. L.D.B.

FEEDS AND FEEDING

220. Palatability of Soybean Meals for Dairy Cows. C. F. Monroe and C. C. Hayden. Ohio Agr. Exp. Sta., Bimonthly Bulletin XXIII, No. 195, pp. 209–214, Nov.–Dec., 1938.

Several palatability trials were conducted with soybean meals representative of those found on the market.

In one trial in which the meals were fed alone, free-choice, a decided preference was shown for expeller meal. Hydraulic meal was second and extracted meal third. Factors other than palatability may have influenced these results.

In one short trial (28–57 days) in which the meals were incorporated in grain mixtures to the extent of 20 per cent, no preference was shown. In a similar trial of longer duration (83–179 days) the order of preference was: extracted, expeller, hydraulic. In a fourth trial a heat-treated extracted meal replaced the hydraulic meal. The grain mixture containing the extracted meal was again preferred, the expeller mixture was second, and the heat-treated extracted meal was a poor third. However, when the grain mixture containing 20 per cent of the heat-treated extracted meal was fed to the same cows and no choice was allowed, it was consumed in normal quantities. W.E.K.

ICE CREAM

221. Report of Committee of Ice Cream Sanitation. International Assn. of Milk Sanitarians, F. W. Fabian, Chairman. J. of Milk Techn. *1:* 4, 20, 1938.

This report deals largely with fountain sanitation, counter freezers and chemical sterilization.

The subjects of total food solids standards for ice cream and controlling overrun are discussed.

Possible contamination due to materials added after pasteurization and methods for solving the problem are given.

The proposed new media and incubation temperature for standard agar plate counts are discussed. L.H.B.

222. **Preparation of Ice Cream Mixes for Home Consumption.** W. J. CORBETT AND P. H. TRACY, Dairy Husbandry Dept., Univ. Ill., Urbana, Ill. Food Research *3:* 6, 637, Nov.–Dec., 1938.

Studies dealing with the manufacture of a canned, sterile ice cream mix for home freezing indicated that such a product should be sterilized using a high temperature–short time procedure, should contain not more than 36 per cent total solids and 9 per cent serum solids, should be homogenized at medium pressures using two stages and should be flavored (if flavors are incorporated) with those which do not affect the heat coagulation point. F.J.D.

223. **Chemical and Bacteriological Studies on Ice Cream.** CECILY R. GRUMBINE AND EVELYN G. HALLIDAY, Home Economics Dept., Univ. Chicago, Chicago, Ill. Food Research *3:* 6, 653, Nov.–Dec., 1938.

A chemical, bacteriological, physical and economic analysis of different brands of vanilla ice cream sold in the Chicago area. F.J.D.

MILK

224. **Sanitary Problems in Connection with the Use of the Homogenizer.** W. J. CORBETT, Dept. of Dairy Husbandry, Univ. of Ill., Urbana, Ill. Milk Dealer *28:* 4, 42–46, 1939.

Bacterial counts on regular and homogenized milk at the University creamery are given.

Data are given showing that when pasteurized milk with an average bacterial count of 1182 was homogenized, the average count of the homogenized milk at the beginning of the run was 1980, in the middle of the run 1510, and at the end of the run 1420. When the average bacterial count of the pasteurized unhomogenized milk was 4125, the count for the homogenized milk was 12,125, 8775, and 6575, respectively, at the beginning, middle, and end of the run.

When sterile milk was homogenized there was a certain amount of "pick-up" by the homogenizer but not nearly as much as the increase in bacterial count in the case of the high-count milk which was homogenized. That the increase in bacterial count of milk, when homogenized, is due to the breaking up of bacterial clumps was shown by inoculating sterile milk with *staphylococcus aureus* and with *B. coli.* The milk inoculated with staphylococcus, which exists in clumps, practically doubled; while that

inoculated with *B. coli*, which exists singly or in pairs, showed no significant increase in bacterial count when homogenized.

Data are presented showing that where milk was homogenized prior to pasteurization there was some increase in bacterial count and that the keeping quality of homogenized milk, as measured by increase in bacterial count, was not equal to unhomogenized milk. The latter is explained on the basis that during the homogenizing process some rapid-growing organisms are picked up and multiply very rapidly when the milk is held at temperatures above 50° F. C.J.B.

EDITOR'S NOTE:—In all cases the homogenizer used in this study was carefully washed, dried with compressed air and sterilized with chlorine before using so as to reduce bacterial contamination to a minimum. The new improved type of high pressure machine was used.

225. Observations on the Development of Rancidity in Sweet Milk, Cream, Butter. J. L. KEITH, Oklahoma A. & M. College, Stillwater, Okla. Milk Dealer *28:* 4, 82–84, 1939.

By comparing milk from cows known to produce milk which became rancid regularly with that from cows known to produce normal milk, the following facts were brought out:

When the rancid milk was separated, the off-flavor was intensified in the cream and in most instances, completely absent in the skim milk.

The separator was equally efficient in removing fat from normal and rancid milks.

The rancid samples of cream foamed more profusely than the normal samples and in most instances required a longer time to churn.

No significant differences were noted in the size, shape, or number of fat globules of the normal and rancid samples.

A greater degree of hydrolysis was definitely indicated in the rancid samples.

Churning cream from the cows which produced milk which became rancid was accomplished with less difficulty if the cream was pasteurized or churned raw before the off flavor developed.

The butter became rancid and otherwise off-flavored immediately or within a few days in storage at 40° F.

The flavor of the milk of the college herd was noticeably improved when milk which developed rancidity was not included. C.J.B.

226. Better Milk Production. Anonymous. Milk Dealer *28:* 4, 48–52, 1939.

A description of the part which 4-H dairy clubs are playing in teaching better methods of milk production. The outline of a typical demonstration is also given. C.J.B.

227. **Controlling Cream Quality in the Plant.** N. E. LAZARUS, President, Lacteal Analytical Laboratories, Buffalo, N. Y., Milk Dealer *28:* 5, 34–35, 68–72, 1939.

The causes and methods of preventing plug formation, oiling off, serum separation, poor viscosity, high bacterial counts, off flavors, poor whipping, lipolytic enzyme activation, feathering, air incorporation, high acidity, and destruction of fat clumps in cream are discussed. The following rules are given for the production of fine quality cream.

1. Use only a good quality raw milk supply.
2. Avoid agitation and air incorporation from raw supply to finished product.
3. Do not use obsolete apparatus designed for handling milk or by-products.
4. Use pasteurizers to at least 70 per cent capacity.
5. Do not use over capacity pumps with high r.p.m. but synchronize the flow of milk and cream with positive type pump.
6. Cool cream only to 48 degrees F. and allow to cool down to 38 degrees F. in a 24-hour aging period in the cooler, without agitation.
7. Handle cream gently at all times.
8. Separate cream at 80–84 degrees F. for increased viscosity.
9. Use recording thermometers—don't guess at temperatures. C.J.B.

228. **Research with Cream at the Massachusetts State College.** MERRILL J. MACK. J. of Milk Techn. *1:* 4, 50, 1938.

This paper enumerates the desirable characteristics of cream. Factors causing oiling off of cream in coffee and means of preventing are discussed as are the whipping properties of cream.

In conclusion, it is stated that, in general, defects in cream are due to excessive agitation in processing, too rapid heating, or reprocessing. Cream should be handled the minimum number of times, carefully pasteurized, and cooled, and marketed when fresh. L.H.B.

229. **What the Colleges Are Doing in the Training of Milk Sanitarians.** FORDYCE ELY, Prof. of Dairy Husbandry, Univ. of Ky., Lexington, Ky. J. of Milk Techn. *1:* 4, 43, 1938.

This paper gives data obtained mostly from a questionnaire sent to the heads of dairy departments in the various land-grant agricultural colleges in the U. S. Response came from 37 states.

The data showed that an average of 18 credits is offered in specialized dairy courses in the various colleges of agriculture which are considered to be extremely valuable in training milk sanitarians. About 175 students are graduated each year who have taken these courses, but during the past five years only about one-sixth of them have entered this field of work.

Thirteen states offer short courses or conferences valuable for training milk sanitarians. L.H.B.

230. Modern Methods of Milk Plant Inspection. MAURICE H. SHORAGO, Consultant to the Dairy Industry, Boston, Mass. J. of Milk Techn. *1:* 4, 32, 1938.

A discussion of points needing especial attention, and tests which will aid an inspector in doing a more thorough job of inspecting are given. L.H.B.

231. Practical Farm Sterilization. ARTHUR H. WILLIAMSON, State Dairy Supervisor, Florida State Board of Health, Jacksonville, Fla. J. of Milk Techn. *1:* 4, 14, 1938.

This paper gives a thorough discussion pertaining to the construction of steam chests for use on dairy farms. L.H.B.

232. The Problem of Recontamination of Pasteurized Milk and Its Products. L. C. BULMER, Director, Bureau of Food and Dairy Inspection, Jefferson County Board of Health, Birmingham, Ala. J. of Milk Techn. *1:* 4, 10, 1938.

The fact is stressed that much effort has been expended in obtaining proper pasteurization of milk and dairy products, but little effort has been made towards preventing recontamination of the products.

It is advocated that the product should flow directly from pasteurizer to the final container. This would include ice cream mix and would prohibit the freezing of ice cream mix in any establishment other than where it was pasteurized.

Covered lips for milk bottles and dating cap are also advocated.

The U. S. Standard Milk Ordinance is also discussed. L.H.B.

233. A Colorimeter for the Phosphatase Test. W. H. BOYNTON AND P. E. NELBACH, Dept. of Public Health, Yale Univ., School of Medicine, New Haven, Conn. J. of Milk Techn. *1:* 4, 8, 1938.

Directions and diagrams are given for making a colorimeter for use with the Gilcrease and Davis standards for the phosphatase test. L.H.B.

234. The Cleaning of Milk Utensils. L. H. BURGWALD. Ohio Agr. Exp. Sta., Bimonthly Bull. XXIV, No. 196, p. 4, Jan.–Feb., 1939.

Bacterial counts made on 5-gallon milk cans, some of which had been kept dry after washing and others wet with sterile water, showed that in 24 hours at room temperature the wet cans contained many more bacteria than just after washing, whereas the cans that were kept dry showed prac-

tically no increase in bacteria. It was estimated that milk put into the wet cans after 24 hours would be contaminated with 6,680 bacteria per cc.
W.E.K.

MISCELLANEOUS

235. Dairy Detergents: Their Analysis and Valuation. W. L. DAVIES. Dairy Ind. *4:* 1, 3, 1939.

Simple tests for determining detergent strengths of soaking-tank solutions and simple tables for solution standardization are recommended to increase the efficiency of bottle cleaning and sterilization.

In evaluating the detergent strength of a solution the "effective alkalinity" is taken as a rough index. All of the compounds of an alkali mixture are evaluated on their equivalent as caustic soda (caustic soda effective alkalinity considered 100). A pH of 11 is considered the minimum alkalinity tolerated by bacteria. Because of the dilution of soaking-tank solutions a solution with a pH well above the minimum is desirable. The effective alkalinity of the common basic washing compounds (referred to 98 per cent caustic soda with an effective alkalinity of 98 per cent) are, 58 per cent soda ash—29 per cent alk., sodium meta silicate—44 per cent alk. and tri sodium phosphate—18 per cent. Sodium meta silicate and tri sodium phosphate show up unfavorably because of their high percentage of water of crystallization.

Analytical methods are described and the analyses of a number of commercial detergent mixtures are shown. D.V.J.

236. Chemical Conservation of Manure. C. J. SCHOLLENBERGER. Ohio Agr. Exp. Sta., Bimonthly Bull. XXIII, No. 195, pp. 219–220, Nov.–Dec., 1938.

In a discussion of the advisability of using phosphoric acid or superphosphate for preventing ammonia losses from manure, it is shown that such a procedure is unprofitable. The use of acid peat moss appears to be a more promising means for conserving nitrogen in manure than does the addition of chemicals. W.E.K.

PHYSIOLOGY

237. Thyroid Stimulation by Cold Including the Effect of Changes in Body Temperature upon Basal Metabolism. G. C. RING, Dept. of Physiology in the Harvard Medical School, Cambridge, Mass. Am. J. Physiol. *125*: 2, 244, 1939.

Living for three weeks or more at 0° to 5° C. produced in rats an average elevation in metabolism of 21 per cent. Corrected for changes in body temperature this figure becomes 16 per cent. This increased metabolism is brought about largely if not entirely by the thyroid gland. Nervous pathways through the superior cervical ganglia are not essential for bringing about stimulation of the thyroid gland by cold. D.L.E.